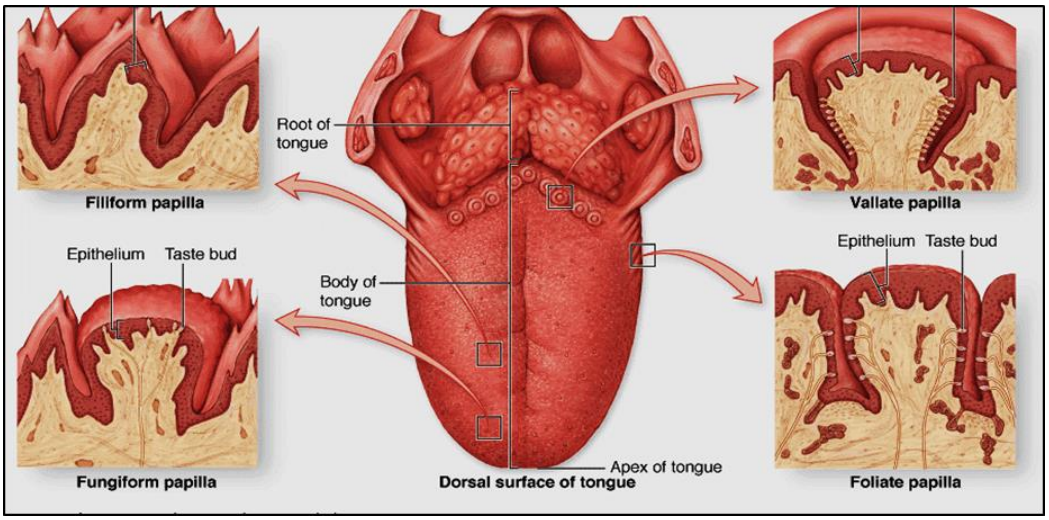
National University of Sadat City

Faculty of Veterinary Medicine

Note on
Cytology & Histology B



For First year Students

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THE DIGESTIVE SYSTEM

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Digestive System

- The digestive system also called *the alimentary tract* extends from the oral cavity to the anus. The main functions of the digestive system are processing, digestion and absorption of food, following by elimination of the residue.
- It is composed of oral cavity, digestive tract and glands.

Components of the digestive system:

I. Oral cavity:
1. Lip
2. Cheeks
3. Tongue
4. Teeth
5. Palate
6. Pharynx

II. Digestive tract:
1. Oesophagus
2. Stomach
3. Small intestine
4. Large intestine
5. Anal canal

III. Digestive glands:
1. Glands in the wall of the digestive tract
2. Salivary glands (minor & Major)
3. Pancreas
4. Liver

I. Oral Cavity

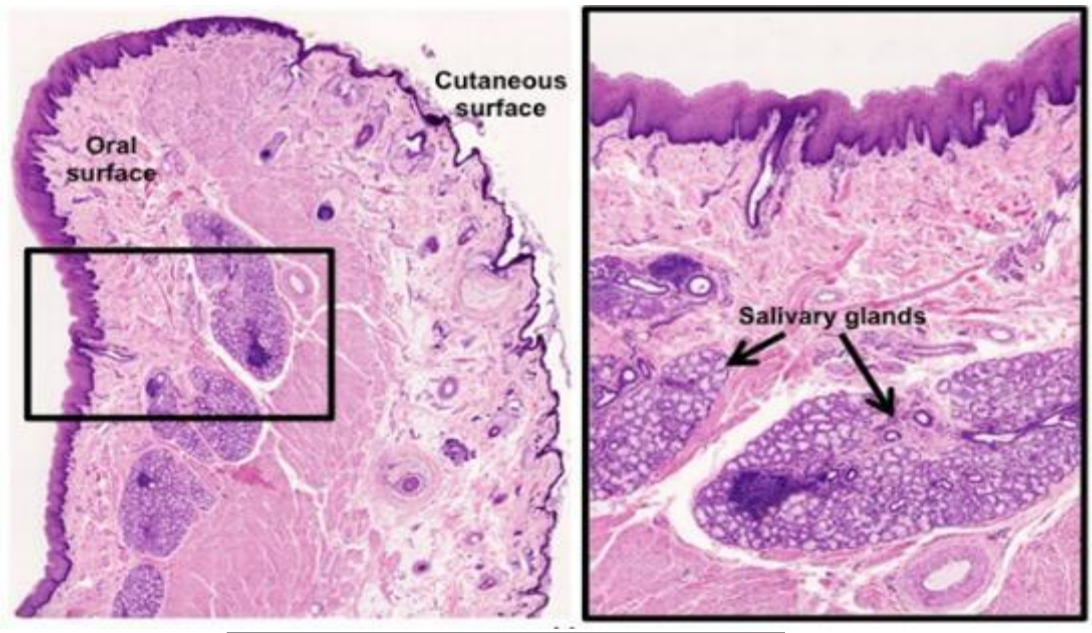
- The oral cavity is the first portion of the digestive tract, and consists of the lips, cheeks, teeth, tongue, palate, pharynx, and associated salivary glands.

Function:

- The oral cavity is the site of mechanical and enzymatic digestions.
- It is involved in speech (the tongue) and taste sensation (taste buds).

Lips

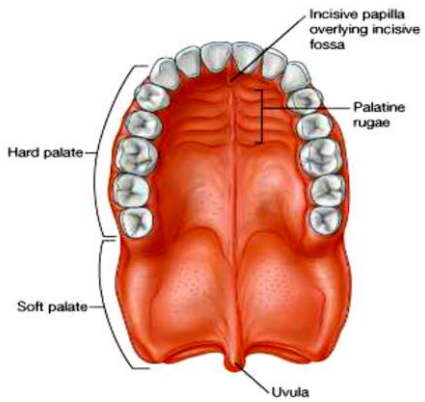
- The lip is covered externally by the skin with its hair follicles, sweat glands and sebaceous glands.
- Internally it is covered by mucosa membrane; which is consists of stratified squamous epithelium keratinized in ruminants and horse and non-keratinized in carnivores.
- Lamina propria of dense fibroelastic connective tissue containing seromucoid, labial glands, and blood capillaries.
- The core of the lip composed of striated muscle bundles, *orbicularis oris* muscle, arranged in different directions.
- The skin covered the outer surface of the upper lip of large ruminants is modified and form the muzzle.
- In human, the free red margin or *vermillion* border is covered by transparent modified skin without glands or hair follicles. Its redness is caused by blood capillaries of the underlying connective tissue.

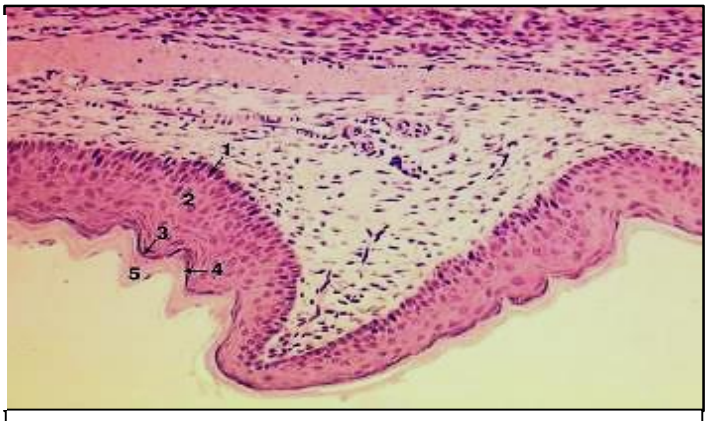


Histological structure of the lip

Hard palate

- It covers the bony roof of the oral cavity and tightly connected with the periosteum.
- The hard palate is lined by highly keratinized stratified squamous epithelium in its rostral part forming rugae palatine.
- The propria-submucosa of dense connective tissue containing venous plexuses or cavernous tissue and is firmly attached to the periosteum of the overlying palatine bone.
- Aggregates of compound tubuloacinar seromucoid glands are found in the caudal part of the hard palate of all animal species except *the pigs*.
- The ***dental pad*** is the rostral thickening of the hard palate replacing the upper incisor teeth *in ruminants*.

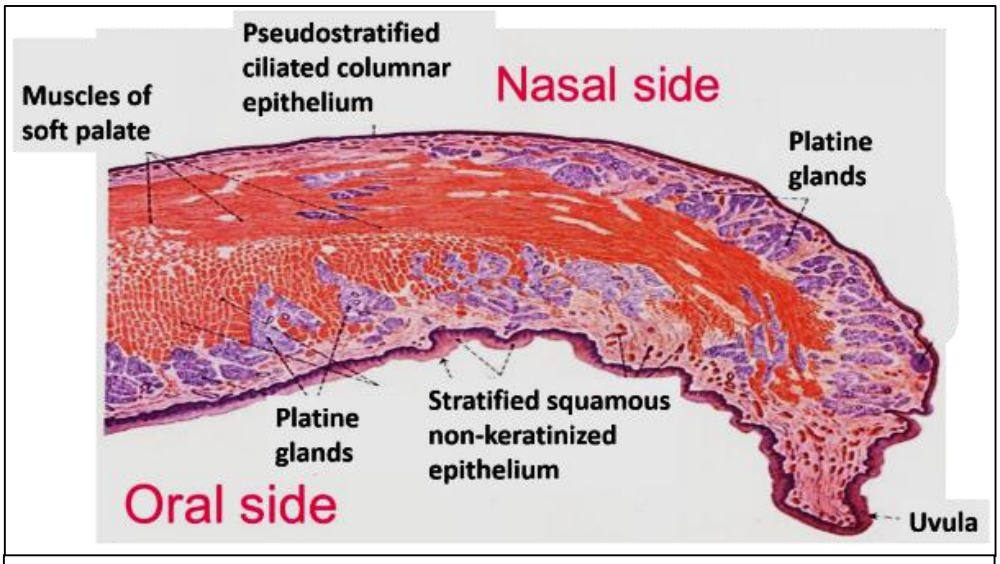




Histological structure of the hard palate

Soft palate

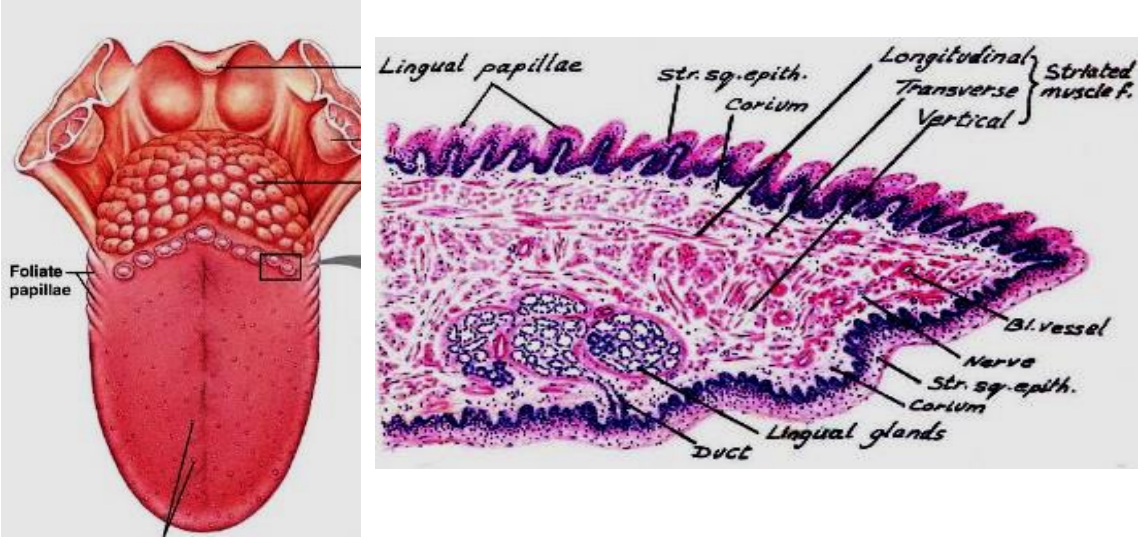
- It is a fold of mucosa that continues caudally from the hard palate and ventrally to the pharynx. It contains oral and aboral (nasal) surfaces.
- Its oral surface is lined by stratified squamous non-keratinized epithelium, while the aboral surface lined by respiratory epithelium.
- Its core is composed of longitudinally directed skeletal muscle fibers, loose connective tissue, seromucoid glands (palatine salivary glands) as well as diffuse and nodular lymphoid tissues.



Histological structure of the soft palate

Tongue

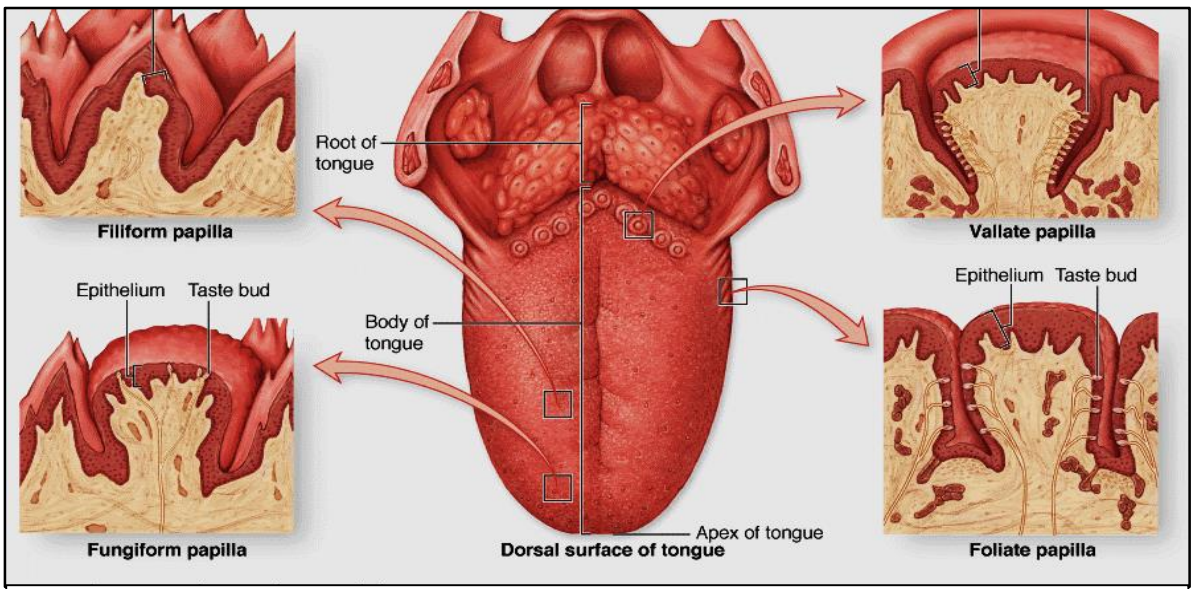
- The tongue is a muscular organ composed chiefly of striated muscles fibers arranged in different directions.
- It is divided into anterior two-thirds (body) and posterior one-third (root) by a V-shaped sulcus terminalis.
- The ventral surface of the tongue is smooth and is covered by thin non-keratinized stratified squamous epithelium continuous with that of the floor of the mouth.
- The core of the tongue contains minor salivary glands, motor and sensory nerve fibers and skeletal muscles.
- The dorsal surface is covered by stratified squamous keratinized epithelium that forming small projections called lingual papillae.



The tongue	Histological structure of the tongue

Lingual papillae

- It is small elevations found on the dorsal surface of the tongue.
- Each papilla is formed a connective tissue core covered by stratified squamous keratinized epithelium.



The tongue and lingual papillae

- There are two types of lingual papillae: mechanical and gustatory papillae.

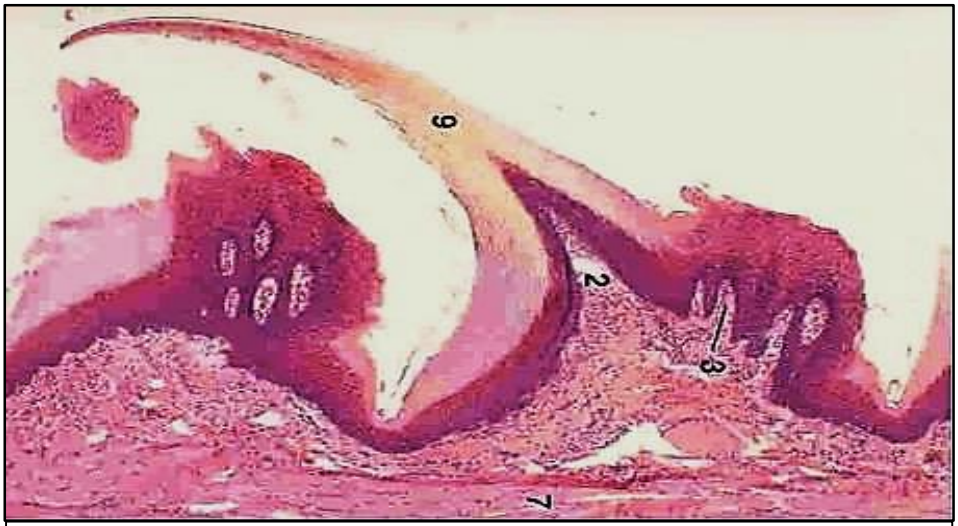
1. Mechanical papillae:

- They contain no taste buds and are principally concerned with movement of foods within and into the oral cavity.
- They include *filiform*, *conical* and *lenticular* papillae.

a. Filiform papillae

- The filiform papillae are the most numerous types.
- They are thread like structure directed caudally, each composed of connective tissue core covered by highly keratinized epithelium.
  - In cat are large with two prominences of unequal size. The caudal prominence gives rise to a caudally directed spine. The rostral papilla is rounded with a thinner stratum corneum.

Histological structure of the filiform papillae



Filiform papillae of cat

b. Conical (Coniform) papillae

- They are cone-shaped structures, larger than filiform papillae.
- They are composed of connective tissue core carrying secondary papillae and keratinized epithelium.
- They occur on the root of the tongue in dog, cat and pig.
- In ruminants, they occur on the inner side of the cheeks and lips.

Conical papillae

c. Lenticular papillae

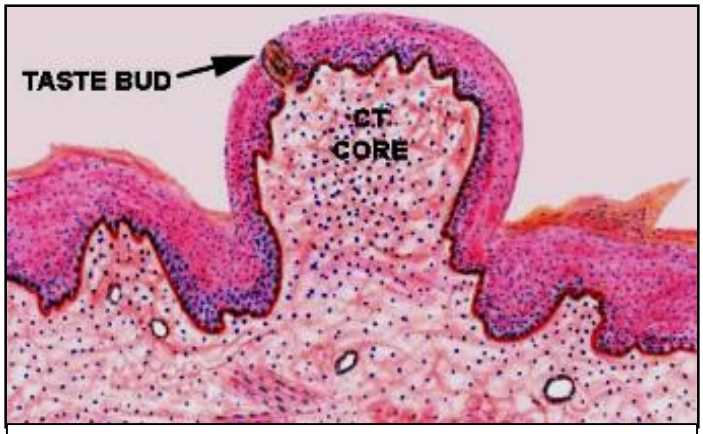
- They are distributed on the dorsal surface of the lingual prominence found on the caudal part of the tongue of ruminants.
- They are covered by keratinized epithelium and have mechanical and in some species gustatory role were recorded.

2. Gustatory papillae: -

- They contain taste buds concerned with the taste sensation.
- They include *fungiform, circumvallate* and *foliate* papillae.

a. <u>Fungiform papillae</u>

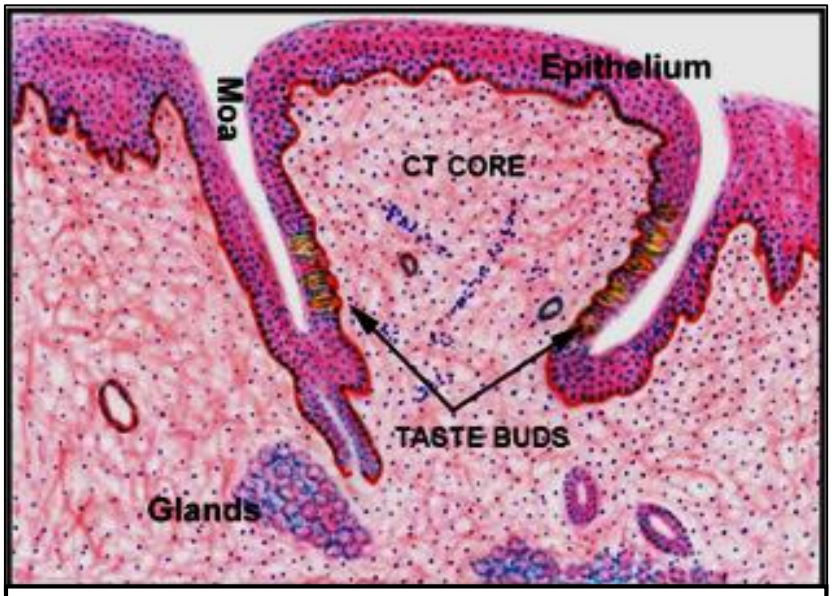
- They have thin non-keratinized epithelium and richly vascular connective tissue core. They rise above the general level of the filiform papillae, and they usually have taste buds in the upper epithelial surface.



Fungiform papillae

b. <u>Circumvallate or vallate papillae</u>

- Vallate papillae are the largest type, easily visible with the naked eye in most animals
- They are located just anterior to the sulcus terminalis, between the root and the body of the tongue.
- Button-shaped and surrounded by a narrow moat; lateral wall of papilla possesses taste buds.
- Aggregates of serous glands called ***Von-Ebner's*** glands whose ducts open into the moat are located beneath the papilla.
- The serous secretions of these glands help to flush up the moat and thus facilitate taste reception.



Circumvallate papillae

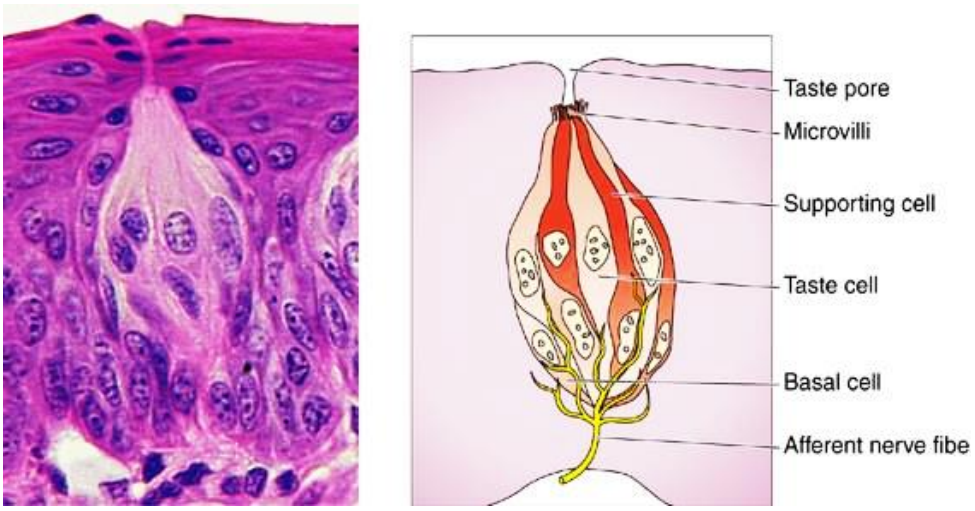
c. <u>Foliate papillae</u>

- The foliate papillae are parallel, leaf like mucosal projections located in the lateral borders at the root of the tongue.
- The papillae separated from each other by gustatory furrow.
- The taste buds are located in the epithelium forming the sides of the papilla.
- The foliate papilla is best seen in rabbits. They are absent in ruminants and rudimentary without taste buds in cats.

The histology of the foliate papillae

Taste buds

- The taste buds are specialized sensory organs embedded within the epithelium of the gustatory papillae.
- They are also found scattered within the epithelial lining of the throat, soft palate and epiglottis.
- **With LM**, they appear as oval-shaped clusters of pale-stained spindle-shaped cells that occupy the full thickness of the epithelium.
- The taste bud is composed of three types of cells:
  1) **Sustentacular or supporting cells**. Elongated curved cells, spindle-shaped with dark ellipsoid nucleus in the middle.
  2) **Basal (Stem) cells**. They are population of small spherical cells located at the base of each taste bud and act as progenitors for both the gustatory and supporting cells.
  3) **Sensory or taste-receptor cells**. Long narrow cells with pale nuclei in the center. The free ends carry taste hairs containing chemoreceptors. They occupy the most centers of the taste buds and intermingled with the support cells.
- The gustatory cells are communicated with the surface of the papilla through a taste pore.

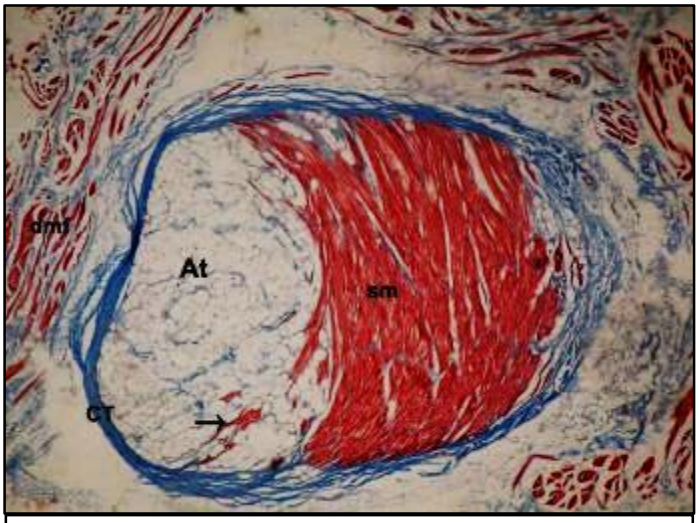


The histology of the taste buds

Special structure of the tongue:

1) The lyssa:

- It is a cord like structure extends longitudinally near the mid-ventral region of the tongue.
- The lyssa is enclosed in a capsule of dense irregular collagenous fibers.
- It is composed of striated muscle fibers, fat cells, blood vessels and nerves and may contain islands of cartilage in its caudal part.
- In dogs, the core of the lyssa is filled with adipose tissue, striated muscle fibers, blood vessels and nerves.
- In cat, it contains mainly fat.
- The tongue of the horse has a mid-dorsal fibroelastic cord with hyaline cartilage, striated muscle fibers and fat.



The lyssa of the dog

2) Torus linguae:

- Found in the dorsal aspect of the ruminant's tongue at its caudal part. It thick highly keratinized dorsal prominence.
- It carries the lenticular and conical papillae.

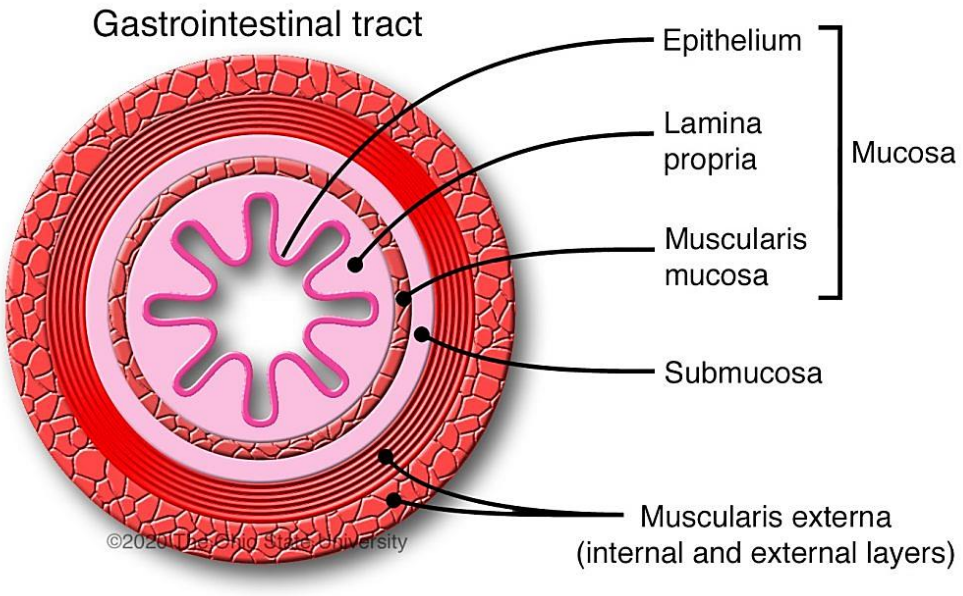
II. Digestive tract (alimentary canal)

- The alimentary canal is a muscular tube extending from the oropharynx to the anus and includes:
  - Esophagus
  - Stomach
  - Small intestine
  - Large intestine
  - Anal canal

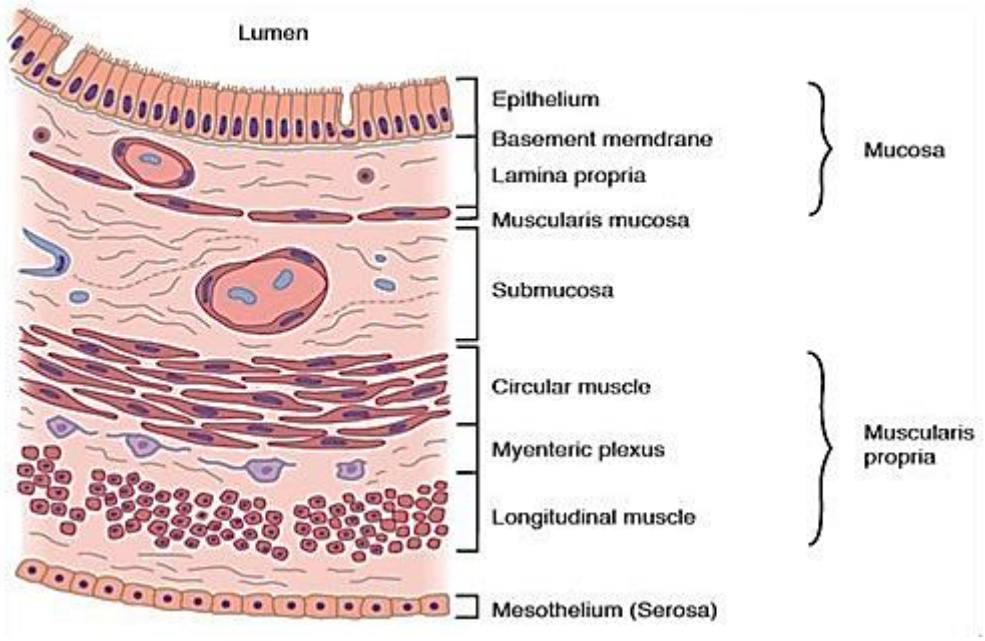
Basic Histological Organization

- The wall of the digestive tract is formed of four main layers; mucosa, submucosa, muscularis externa and serosa (or adventitia).

1. **Mucosa**. Innermost layer facing the lumen.
   - *Lamina epithelialis*. of simple columnar or stratified squamous epithelium.
   - *Lamina propria*. Loose connective tissue; usually possesses glands.
   - *Muscularis mucosa* consists of smooth muscle layer marking external boundary of mucosa and helps in gland secretion.
2. **Submucosa.** Denser connective tissue than the lamina propria. The submucosa possesses Meissner's nerve plexus. The submucosa possesses glands in the esophagus and duodenum.
3. **Muscularis externa** of smooth or skeletal muscle is usually arranged into inner circular and outer longitudinal layers.
   - Auerbach's nerve plexus is located between the two muscle layers and provides innervation to this smooth muscle.
4. **Serosa or adventitia** is a layer of loose connective tissue covered by simple squamous epithelium. When epithelial cover is not present, the layer is called adventitia.



Layers of the gastrointestinal tract



General histological arrangement of the gastrointestinal tract

1. Esophagus

- The esophagus is a straight, long, narrow, muscular tube that transports the chewed-up food from the pharynx to the stomach.

a. Mucosa

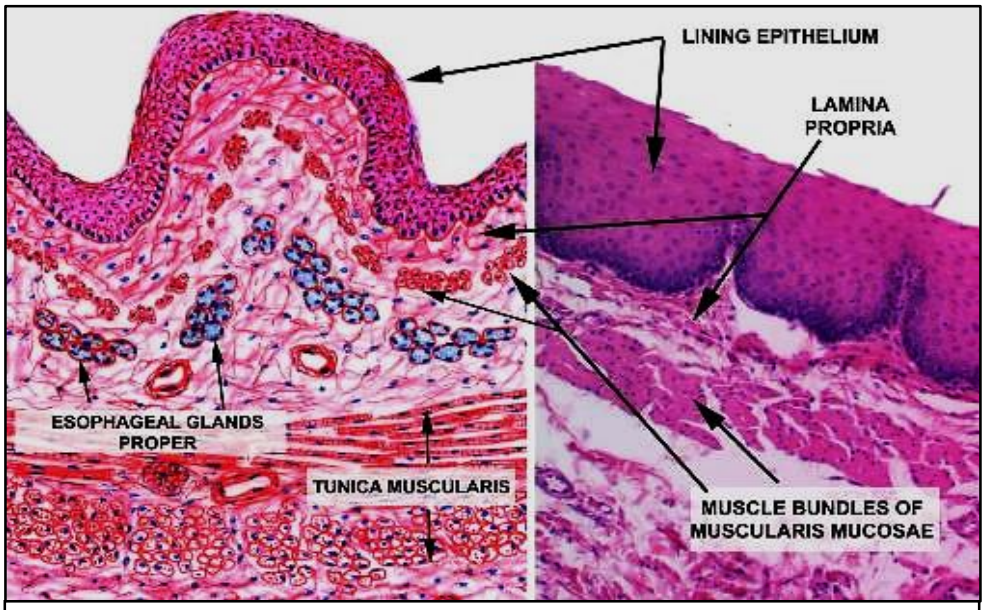
- *Epithelium*. Stratified squamous nonkeratinized epithelium in carnivores and human, and highly keratinized in horse and ruminants.
- *Lamina propria* of dense connective tissue carrying papillary bodies.
- *Lamina muscularis mucosa* of only longitudinally arranged smooth muscle bundles.

b. Submucosa

- It is loose connective tissue contains blood vessels, lymphatics, nerves and seromucoid esophageal glands.

c. Muscularis externa is composed of two layers of skeletal or smooth muscle arranged in inner circular and outer longitudinal layer.

d. Adventitia. Composed of loose connective tissue. The adventitia covers the cervical part of the esophagus, while the serosa covers the thoracic and abdominal part.



The histological structure of the oesophagus human and carnivores

2. Stomach

- The stomach is a dilated part of the digestive tube specialized for mechanical and chemical breakdown of the food into digestible nutrients.

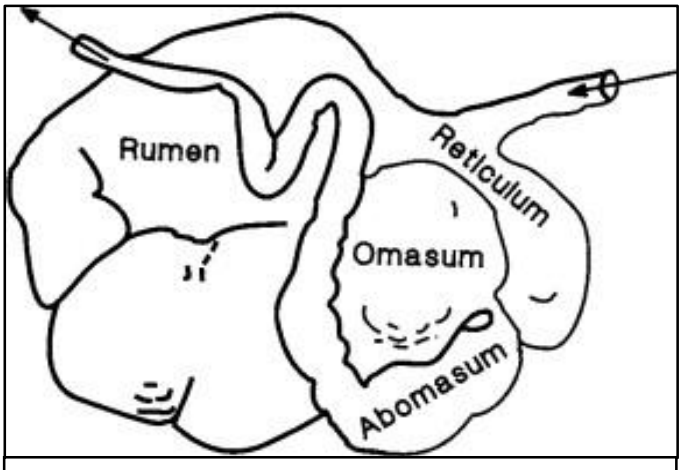
Functional structure: -

1) Mechanical reduction of food is produced by a strong muscle action.
2) Chemical reduction of food is produced by gastric juice.
3) Absorption of food products is very little from the stomach.

- The stomach is classified according to the nature of mucosa and the number of its compartments into:

1. ***Monolocular simple stomach***: composed of one chamber and lined by glandular mucosa as in dog, cat and human.
2. ***Monolocular compound stomach***: composed of one chamber but lined by both glandular and cutaneous mucous membrane as in horse and pig.
3. ***Multilocular compound stomach***: composed of more than one chambers and lined by both glandular and cutaneous mucous membrane as in ruminants.

- In ruminants the stomach has four compartments, three of them (rumen, reticulum and omasum) are called ***fore-stomach or proventriculus***, they are lined by cutaneous mucous membrane
- The abomasum (glandular stomach) is lined by secretory mucous membrane.



Fore-stomach or proventriculus of ruminants

The glandular stomach

- It is lined by secretory glandular epithelium.
- It is the simple monolocular stomach in human, carnivores, the glandular part of compound stomach in horse and pig and abomasum in the ruminants.
  - **Tunica mucosa**. It is thrown into folds called *rugae* that studied by tiny opening, the gastric pits, into them the gastric glands open.
    1. Lamina epithelialis of high columnar secretory cells, its apical halves containing mucigen granules (no goblet cells are seen).
    2. Lamina propria it contains the gastric glands in the area of loose connective tissue.
    3. Muscularis mucosa of inner and outer circular and middle longitudinal layers of smooth muscle fibers.
  - **Submucosa**. Loose connective tissue with elastic fibers.
  - **Muscularis externa**. Of inner oblique, middle thick circular and outer incomplete longitudinal layers of smooth muscle.
  - **Serosa** is a layer of loose connective tissue covered by simple squamous epithelium.

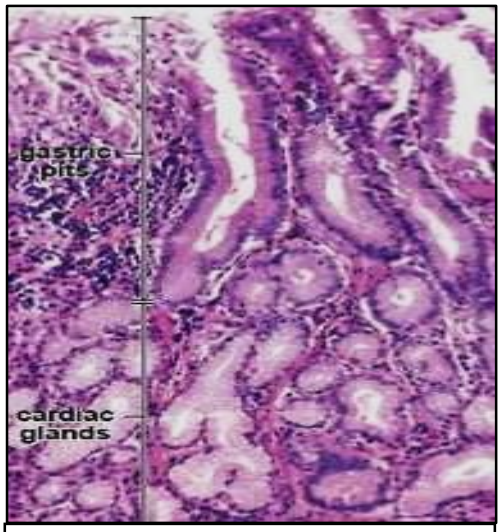
The gastric glands

- There are three major categories of these glands, associated with different parts of the stomach: cardiac, fundic and pyloric regions.
- The glandular regions are wholly confined to the tunica mucosa.

1. The cardiac glands

- The cardiac region represented by narrow strip in the mucosa of the stomach in all domestic mammals except pig where it covers nearly half of the stomach.
- The gastric pits are wide and deep end at the opening of the glands.
- It is simple branched tubular and coiled; the body of the glands are lined by cuboidal mucous secreting cells with round basally located nuclei.

- Occasionally similar glands can be found in the esophagus itself. These are called "esophageal cardiac glands".
- They secrete mucous secretion.



Cardiac glands

2. The fundic glands

- The fundic region is well developed in all domestic species.
- These glands are found in the lamina propria of the mucosa of the fundus and the body. They produce the bulk of secretions in the stomach.
- The fundic glands, like the other types, open into the base of comparatively shallow gastric pits.
- Each gland consists of a neck, a long body and a dilated base or fundus.
- They are straight, simple branched tubular glands which synthesize and secrete gastric juice.
- The fundic glands are lined by stem cells, mucous neck cells, parietal cells, chief cells and scattered endocrine cells.

The cell types of the fundic glands:

1) **Stem cells** are located in the neck of the gastric glands. Some cells divided and moved upward to replace mucous surface cells and others move deeper to differentiate into the other cell types.
2) **Mucous neck cells** are found in the neck of the gland and in the gastric pit. They are smaller than the surface mucous cells.

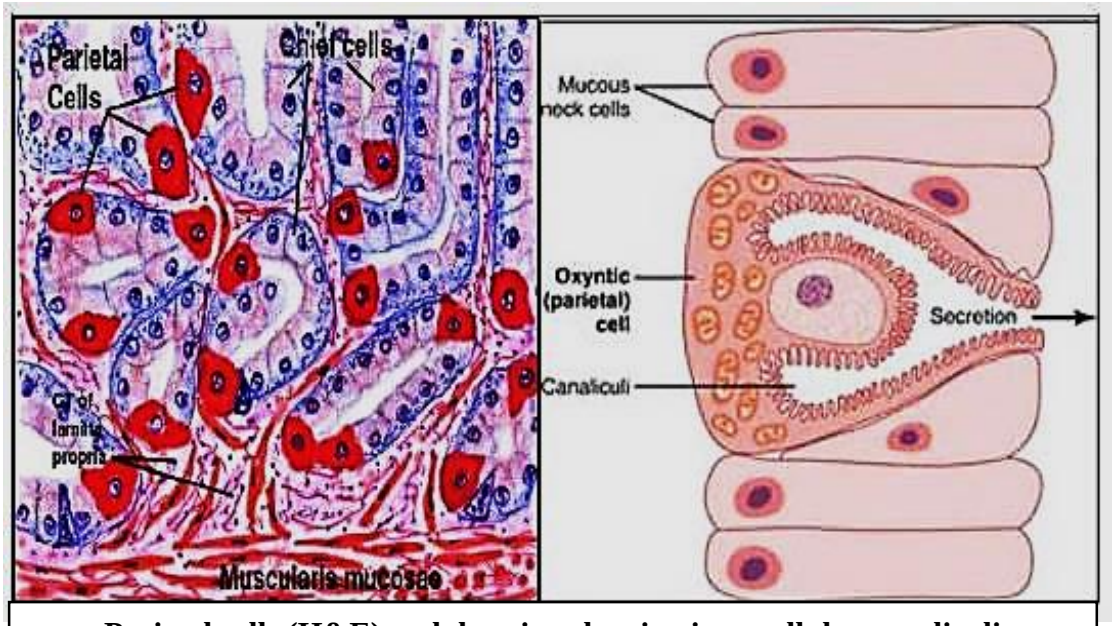
- They differ from surface cells in that they secrete *acidic mucus*.

3) Parietal (*HCl* forming**) cells** are large, spherical, eosinophilic cells that secrete hydrogen and chloride ions and gastric intrinsic factor.

- With LM: they have extensive acidophilic cytoplasm (oxyntic cells).
- The base of the cell bulges outward and its narrow apex reaches the lumen of the gland (parietal cells).
- With EM: the presence of deep ***intracellular canaliculus*** with numerous long microvilli, increasing surface area.
- They possess numerous mitochondria.
- Although present throughout the gland, parietal cells are more numerous in the middle regions and between mucous neck cells.

Function:

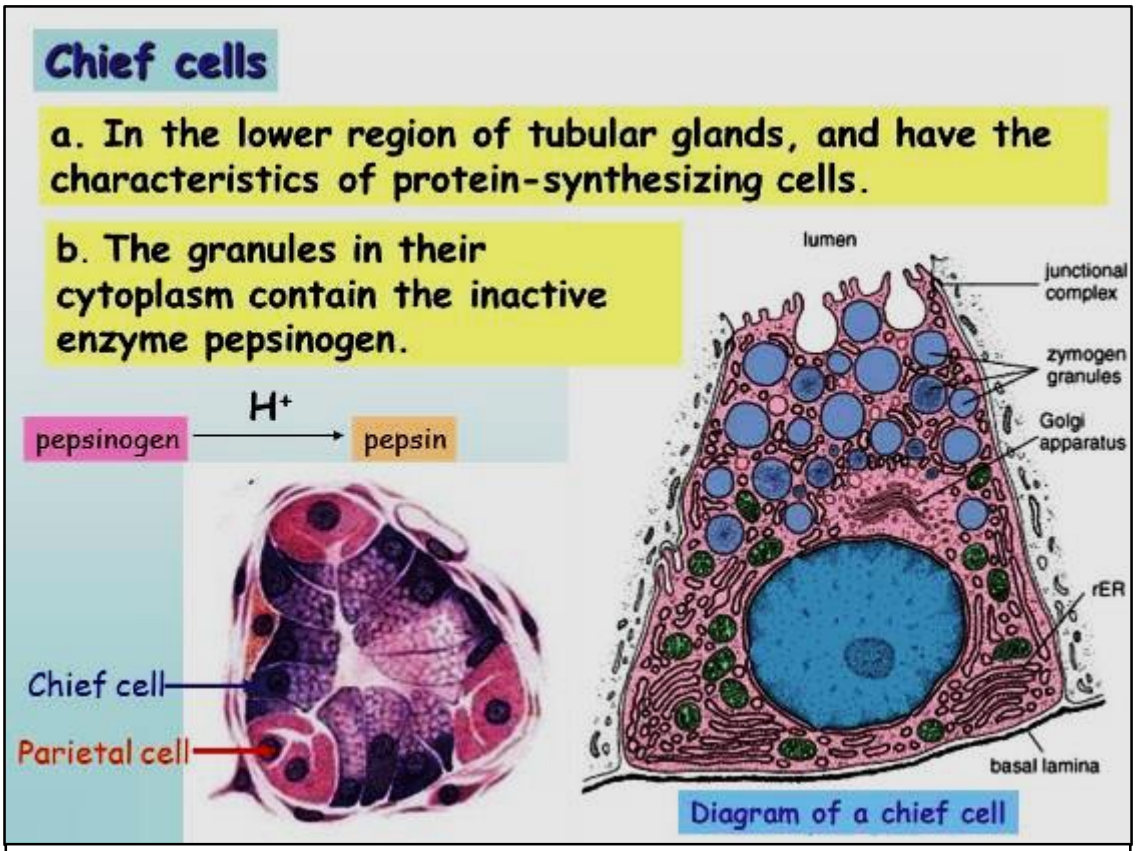
- Formation and secretion of hydrochloric acid (HCl).
- Secretion of the intrinsic factor essential for absorption of vitamin B_{12} in the small intestine.



Parietal cells (H&E) and drawing showing intracellular canaliculi

4) **Chief or zymogen** (peptic) **cells**, predominate in the bases; stain blue with hematoxylin and secrete pepsinogen.

- They are the most numerous cell types within the fundic glands, hence the name chief cells.
- With LM; Chief cells are cuboidal or pyramidal with deep cytoplasmic basophilia, apices aciophilia (zymogen) and vesicular nucleus.
- With EM, the ultrastructure features of protein-secreting cells: include an extensive rER and membrane-bound secretory vesicles (zymogen granules) crowded in the apical cytoplasm.



Chief cells (H&E) and diagram of chief (zymogen) cell

3. The pyloric glands

- The structure of the pyloric gland is similar to that in the cardiac gland.

Variations specific to the pyloric region

- Pits are longer in pylorus than in the cardiac region.
- Pyloric glands not as coiled as in the cardiac region; primarily secrete mucus.
- Enteroendocrine cells are also present here.
- Circular layer of muscularis externa is greatly thickened to form the pyloric sphincter.

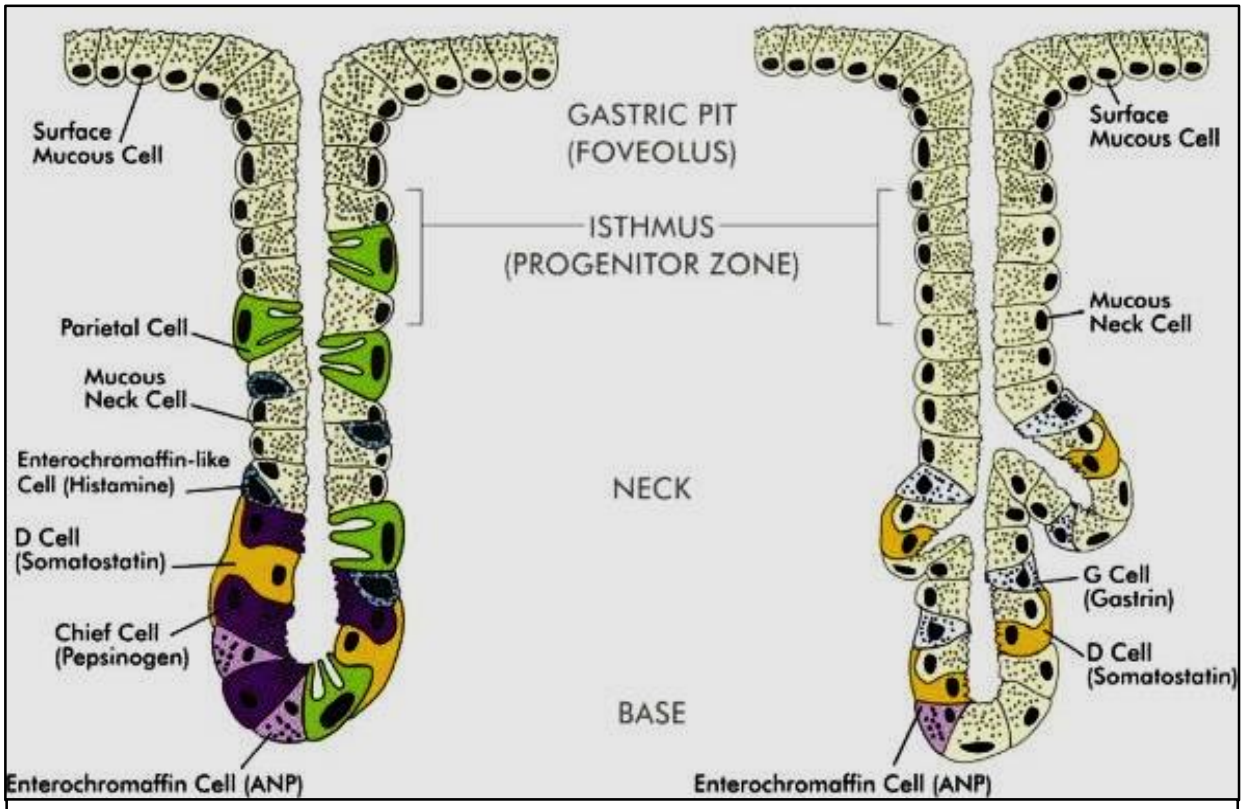


Diagram of the fundic gland **Diagram of the Pyloric glands**

Non-glandular stomach (fore-stomach)

- The non-glandular region is lined by stratified squamous keratinized epithelium derived from that of the esophagus.
- It is entirely absent in carnivores, small in pigs, wide in horse.
- In ruminants, it is subdivided into three distinct compartments; rumen, reticulum and omasum.

a) Rumen

- The rumen represents the large and first compartment of the fore-stomach, act as a fermentation room.
- The rumen is the site for microbial fermentation of fibrous ingesta. Its mucosa is active in the absorption of short-chain volatile fatty acids produced during the fermentation process.
  - **Mucosa**. The ruminal mucosa carries small tongue-shaped papillae called the *ruminal papillae*.
    - L. epithelialis: of stratified squamous keratinized epithelium.
    - L. propria: fibroelastic connective tissue.
    - L. muscularis mucosa: Absent
  - **Submucosa**: of loose connective tissue contains network of blood and lymph vessels. It is blends with propria.
  - **Muscularis externa**: of inner circular and outer longitudinal layers of smooth muscle with myenteric plexus in-between.
  - **Serosa**: of lamina epithelialis serosa and lamina subserosa.

b) Reticulum

- It is lined by cutaneous mucous membrane that forms characteristic permanent folds, which join with each other forming the reticular cells giving the appearance of honey comb. The reticular cells are five or six-sided.

- The large folds are the primary and the small ones that divide the reticular cells are the secondary folds.
  - **Mucosa**:
    - L. epithelialis: St. sq. keratinized epithelium carries on the side and free ends of the reticular folds, conical papillae.
    - L. propria-submucosa: of dense fibroelastic connective tissue.
    - L. muscularis mucosa: there is no lamina muscularis mucosa but smooth muscle band in the upper part of the reticular folds. It is continuous with the muscularis mucosa of the esophagus.
  - **Muscularis externa**: of inner circular and outer longitudinal layers of smooth muscle fibers.
  - **Serosa**: of lamina epithelialis serosa and lamina subserosa.

c) Omasum

- The omasum is involved in mechanical breaking down of the ingesta into fine particles.
- The mucosa is thrown into longitudinal leaf-like folds called omasal lamina.
- They carry horny macroscopic papillae and their free edges are concave.

It is composed of:

- **Mucosa**
  - L. epithelialis: of stratified squamous keratinized epithelium.
  - L. propria: fibroelastic connective tissue.
  - L. muscularis mucosa: two muscular layers on either side of the omasal lamina.
- **Submucosa**: of dese connective tissue.
- **Muscularis externa**: of inner circular and outer longitudinal layers of smooth muscle fibers.

- The inner circular layer sends intermediate layer that extends to free edge of the large omasal lamina.
- Accordingly, each large omasal fold has three muscle layers: two lateral layers derived from the muscularis mucosae, and one central layer originating from the inner circular layer of the tunica muscularis.

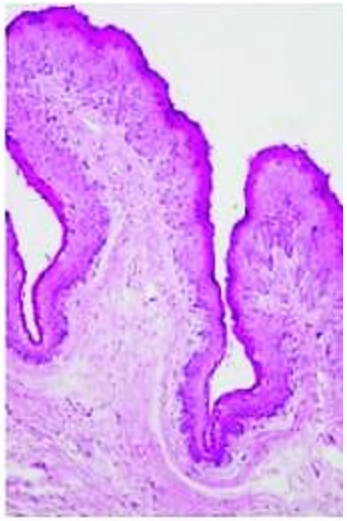
▪ **Serosa**: of lamina epithelialis serosa and lamina subserosa.

d) Abomasum

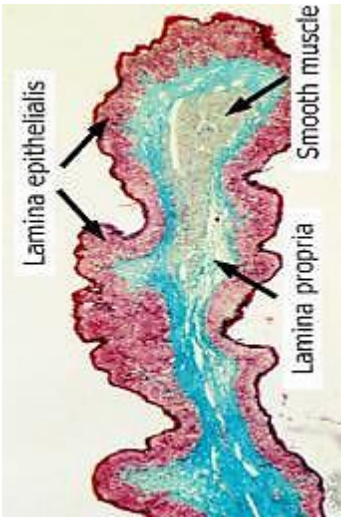
- The abomasum is the true glandular stomach of ruminants.
- Its histology is very similar to the fundic region of the simple stomach.

Vela terminalis (Omaso-abomasal fold)

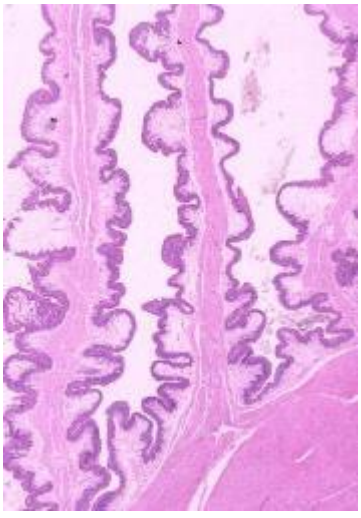
- It is a mucosal fold between the omasum and abomasum, where the epithelium changes abruptly from stratified squamous keratinized to simple columnar epithelium.
- The core of the vela is derived from the submucosa. It contains lymph nodules.



Rumen



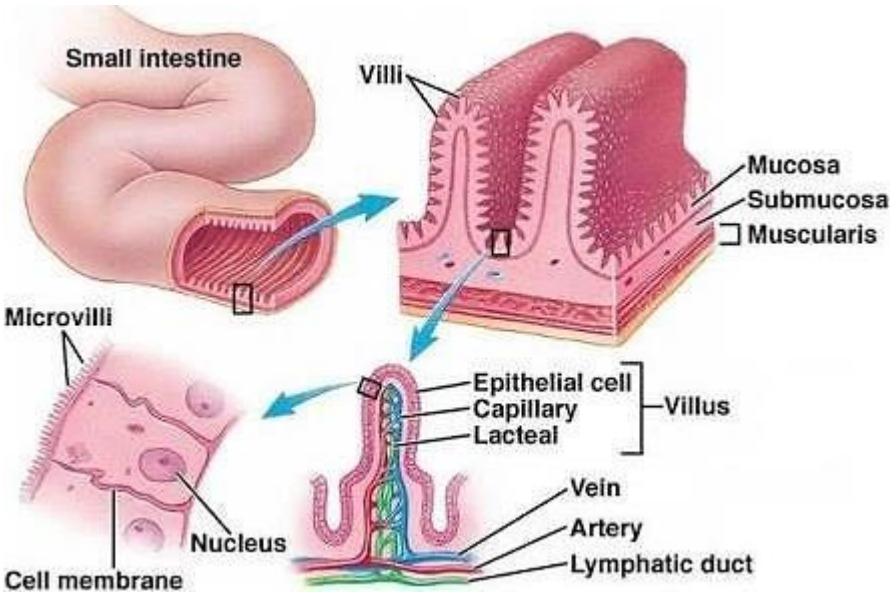
Reticulum



Omasum

3. Small intestine

- The small intestine is responsible for the absorption of nutrients.
- It is subdivided into duodenum, jejunum, and ileum.
- In small intestine the nutrients are hydrolyzed into absorbable form (amino acids, glucose, and fat) and absorbed then transformed to blood and lymph capillaries. The undigested materials moved to the large intestine.



Modification of the intestinal mucosal surface

General structure of small intestine: -

- **Tunica mucosa:** contains finger-like projection called villi.
  - Lamina epithelialis: composed of two types of cells.

  a) **Absorptive cells**, they appear as tall simple columnar epithelium cells with acidophilic brush border (microvilli) and basal nuclei.

b) **Goblet cells** (unicellular glands) are interspersed among absorptive cells and secrete mucus. These cells increase in number from duodenum to rectum.

- Lamina propria: of fibroelastic connective tissue forms the core of the villi contains also lymph vessel (central lacteal) and strands of smooth muscle fibers, which come off the muscularis mucosae.

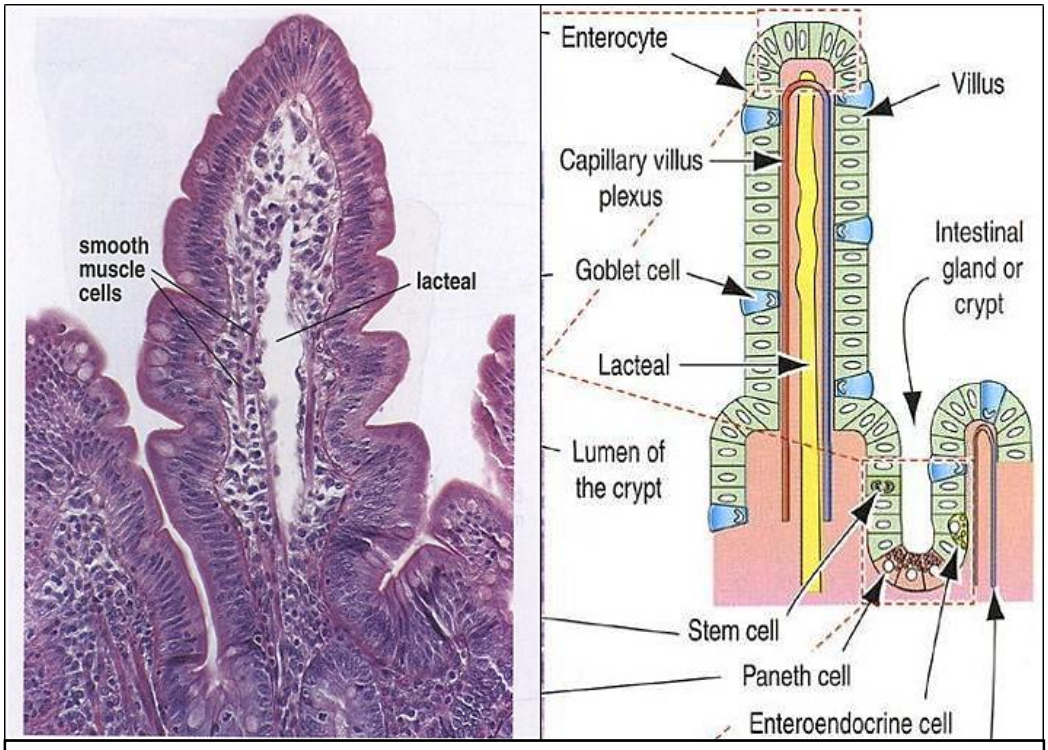
- **Payer's patches** are clusters of lymphoid nodules located primarily in the lamina propria of the ileum
- **Intestinal glands** (***crypts of Lieberkühn***) are simple tubular glands that begin at the bases of the villi in the mucosa and extend through the lamina propria to the muscularis mucosae.
- **It contains different cell types: -**
  1. Absorptive cells (enterocytes).
  2. Goblet cells.
  3. **Paneth cells:** These enzyme secreting cells are placed small groups in the depth of the crypts. They possess large, eosinophilic granules whose contents digest bacterial-cell walls.
  4. Enteroendocrine cells.

▪ **The tunica submucosa** is loose connective tissue.

- Brunner's glands in the submucosa are present only in the duodenum.
- These compound tubular glands open into the bases of the intestinal glands and secrete alkaline mucus to neutralize the acidity of the stomach contents.

▪ **Muscularis externa** of inner circular and outer longitudinal layers with an intervening Auerbach's nerve plexus.

▪ **Serosa** covers all of small intestine except for the beginning of the duodenum, which is retroperitoneal and possesses an adventitia.



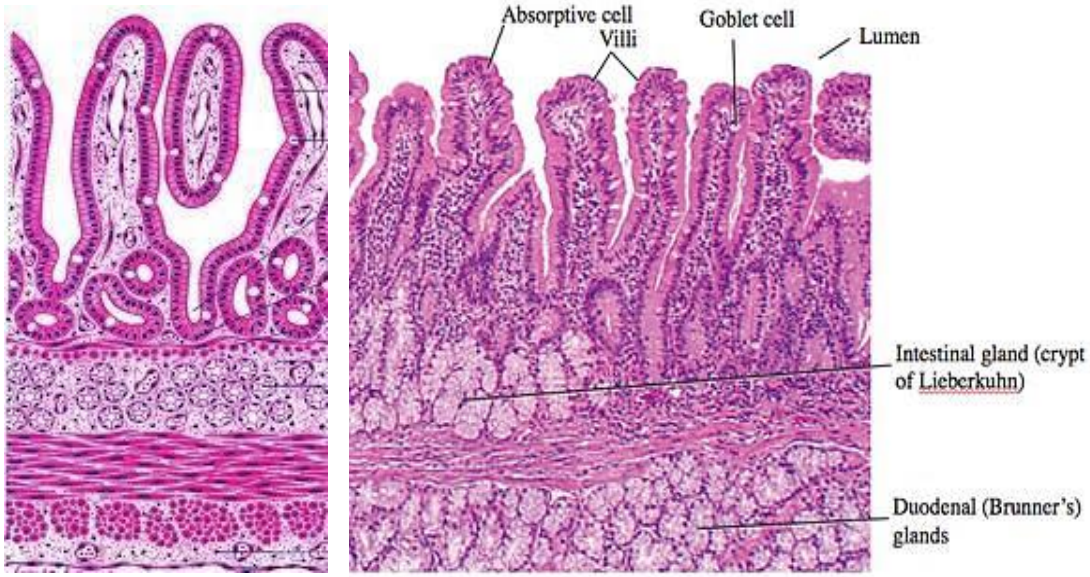
The histological structure of the intestinal villi

Histological differences between duodenum, jejunum and ileum:

a) Duodenum

- The duodenum is the first portion of the small intestine.
- The villi are broad and appear leaf-shaped in longitudinal section.
- Most of the epithelial cells are the absorptive enterocytes with few goblet cells.
- The Paneth cells and enteroendocrine cells are found in clusters at the bases of the crypts. The Paneth cells are pyramidal with large eosinophilic granules.
- The lamina propria is a loose and very cellular irregular connective tissue.
- Within the lamina propria, and up into the core of the villi there are mall strands of smooth muscle, which come off the muscularis mucosae.
- The core of each villus has numerous small capillaries in its lamina propria, and a single large lymphatic vessel, called the central lacteal.
- The submucosa of the duodenum also has true glandular elements, called *Brunner's glands*. They are the characteristic feature of the duodenum.

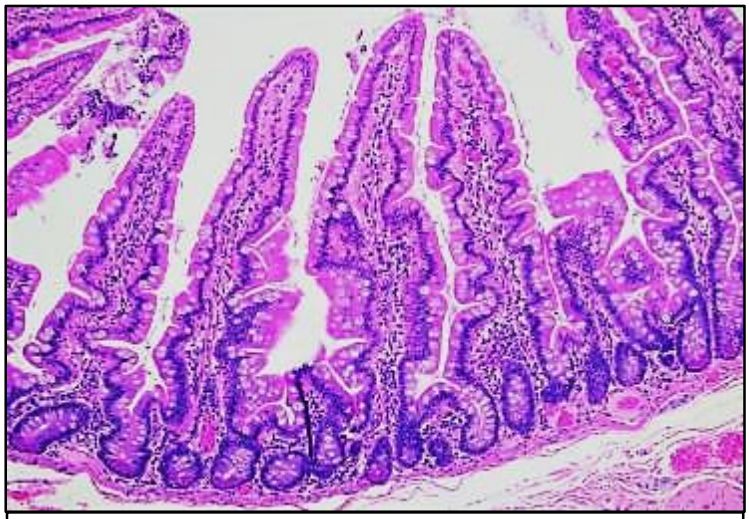
- The Brunner's glands secrete alkaline mucous secretion that protects the duodenal lining from the acidity of the chyme and maintains the pH for pancreatic enzymes.



The histological structure of the duodenum

b) Jejunum

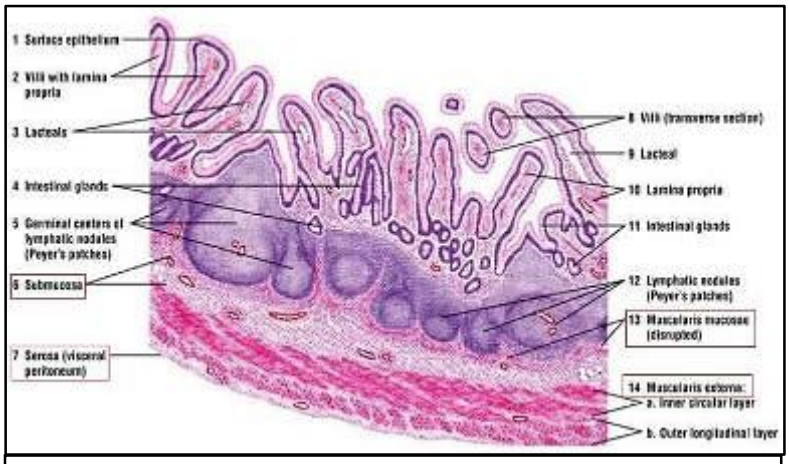
- Jejunal villi are longer and more irregular than the short, blunt villi characteristic of the duodenum.
- Notice that there are no glands in the submucosa in this region.



The histological structure of the jejunum

c) Ileum

- The villi are fewer and narrow in longitudinal section with many goblet cells.
- The most prominent feature in the ileum is the presence of large masses of lymphatic tissue in the submucosa (called Peyer's patches).
- They may penetrate the muscularis mucosa and reach the deep part of mucosa.



The histological structure of the ileum

4. Large intestine

- The large intestine comprises the cecum, colon, and rectum.
- The main function of the large intestine are reabsorption of water and soluble salts, and elimination of wastes.
- No villi or plicae circulares are present in the large intestine.

The mucosa of large intestine process; -

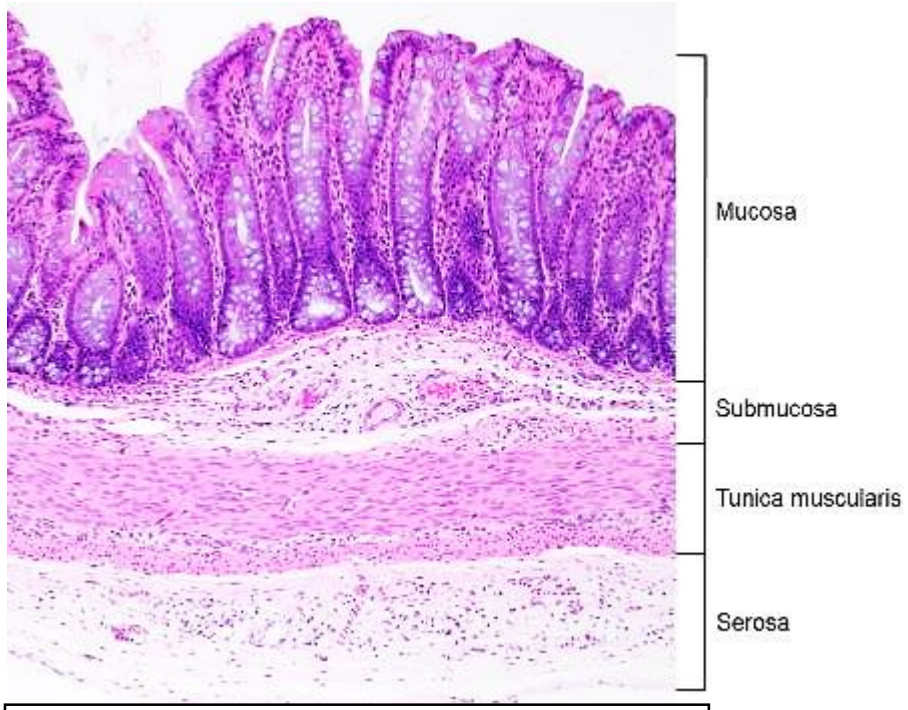
- *L. epithelialis*: the surface of the large intestine is smooth (no villi) lined by different cell types: -.
  - Absorptive cells form a simple columnar epithelium with microvilli.
  - Goblet cells increase in number toward the rectum.
  - The enteroendocrine cells are present.
- *L. propria*: Contains loose connective tissue and simple tubular intestinal glands (crypts of Lieberkühn) which are long and straight. No Paneth cells in the crypts of the large intestine.

Muscularis externa

- Inner circular layer is intact.
- Outer longitudinal layer is segregated into three longitudinal bands, the *taeniae coli*, which are placed equidistantly around the tube.
- Either an adventitia or a serosa is present, depending on the particular portion of the large intestine.

5. Anal canal

- The anal canal connects the rectum to the anal opening.
- The circular smooth muscle constitutes the internal anal sphincter.
- Distal to this, the anal canal is encircled by the voluntary anal sphincter of skeletal muscle.
- The lining epithelium of the anal canal is stratified squamous nonkeratinized epithelium and then to the epidermis of the thin skin.



The histology of the large intestine

III. Glands of the digestive system

1) Salivary Glands

- The salivary glands are structurally compound ***exocrine*** glands they have a duct system that takes secretions (the saliva) from the productive areas to the oral cavity where it well be used.
- They are two major groups; minor and major salivary glands: -

A. Minor salivary glands

- They are simple branched tubulo-alveolar glands which are scattered in the mucosa membrane of the oral cavity.
    - Labial glands (lips).
    - Buccal glands (cheeks).
    - Lingual glands (tongue).
    - Palatine glands (soft palate)

B. Major salivary glands

- They are paired compound tubulo-alveolar exocrine glands.
- Major salivary glands develop from the lining epithelium of the oral cavity and open into it by means of ducts.
    - Parotid glands (serious).
    - Submandibular or submaxillary glands (mixed).
    - Sublingual glands (mixed).

Function of the salivary glands

- Produce saliva to wet, lubricate, and buffer the oral cavity.
- Produce amylase for the initial digestion of carbohydrates.
- Produce lysozyme to control bacteria in the oral cavity.

Duct system conducts secretions to oral cavity:

- Ducts are more numerous with serous acini than with mucous tubules because the tubules can act as their own ducts.

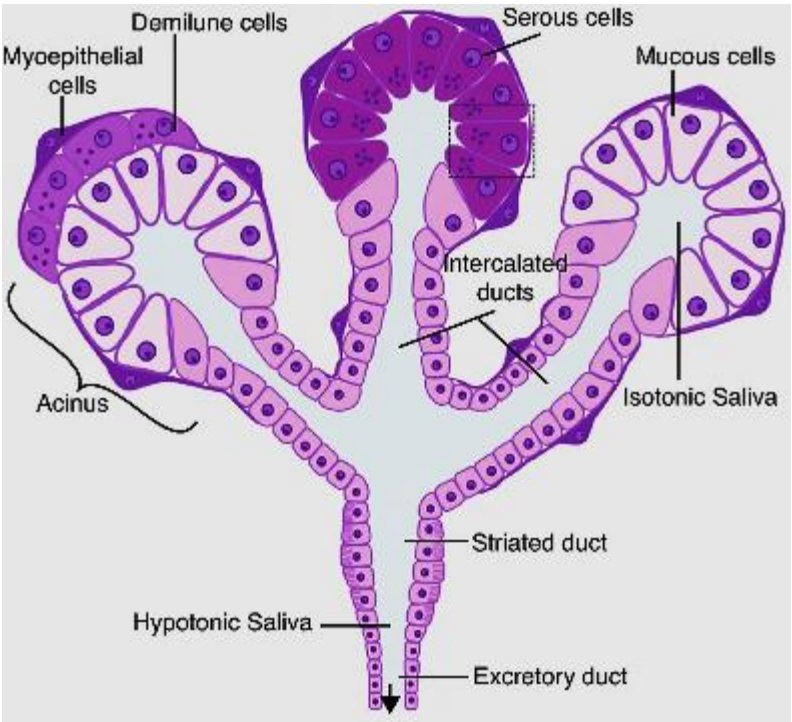
a) Intralobular ducts

- Intercalated ducts exit from secretory acini and are smaller in diameter than the acini they drain. These ducts are lined by simple cuboidal epithelia.
- Striated ducts are larger in diameter than the secretory units they drain. They are lined by simple columnar epithelia.

- Numerous mitochondria and infoldings of the plasma membrane in the basal region of the cells give the duct a striated periphery. Striated ducts alter the content and concentration of the saliva.

b) Interlobular ducts are located in the connective septa between lobules and are lined with simple columnar to stratified columnar epithelia.

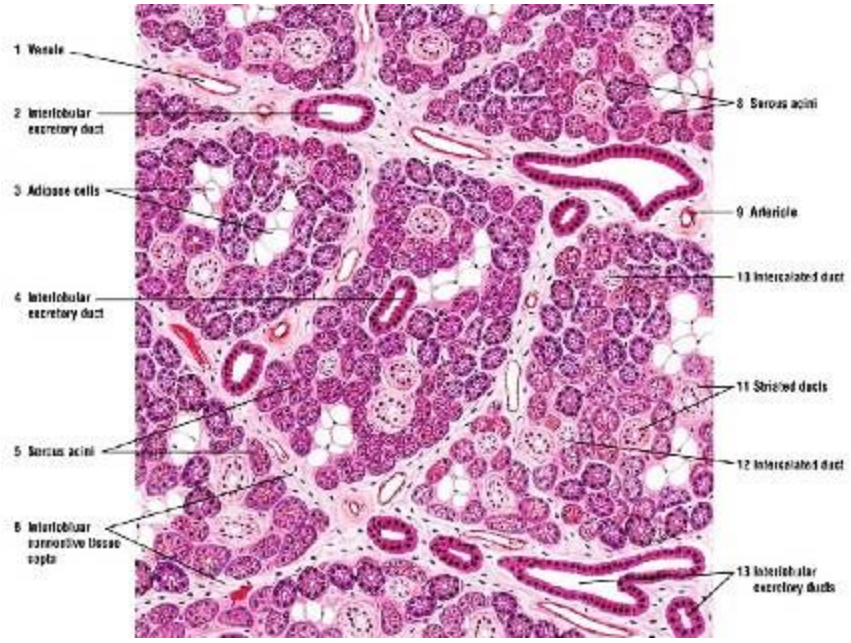
c) The main excretory duct is lined by a stratified epithelium that becomes stratified squamous moist just prior to its junction with the epithelium of the oral cavity.



The acini and the duct system of the salivary glands

1. Parotid glands

- The parotid glands are large paired predominantly serous glands.
- Compound acinar glands producing only serous, watery secretion reach in enzymes; their secretions account for 25% of the saliva.
- Possess the most highly developed duct system of the major salivary glands.



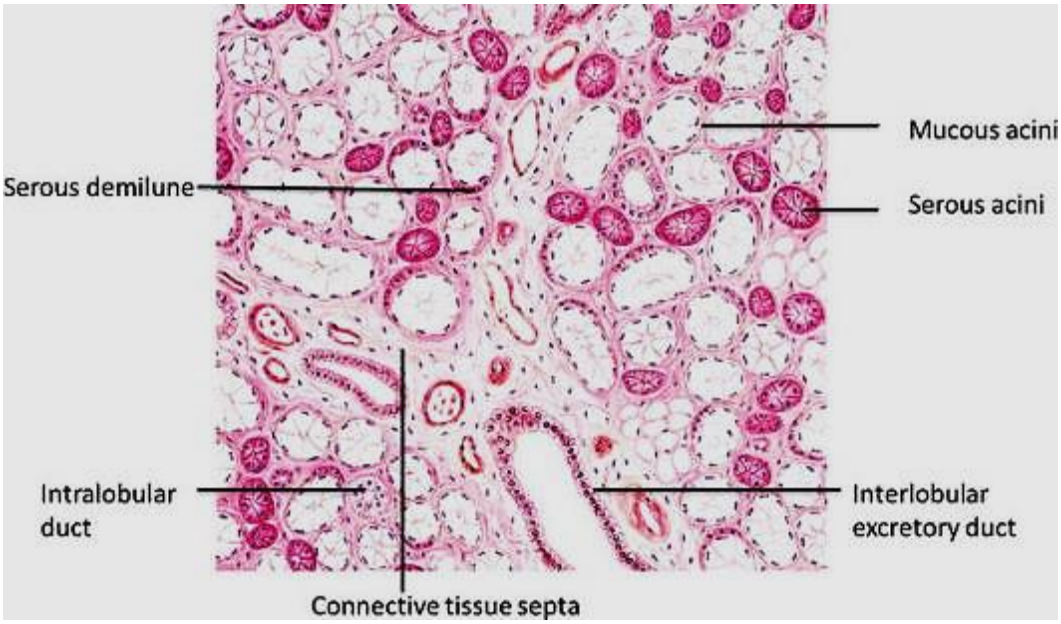
The parotid salivary glands

2. Submandibular glands

- Compound tubulo-alveolar glands producing both serous and mucous products, although serous acini predominate. Their secretions account for 70% of the saliva.
- Serous cells are present as both acini and serous demilunes.

3. Sublingual glands

- Secrete approximately 5% of the saliva. These are compound tubulo-acinar glands, producing both mucous and serous products, although mucous tubules predominate.



The sublingual salivary glands

2) Pancreas

- Located in the abdomen in the curve of the duodenum and divided into a head, body, and tail.
- The pancreas contains both exocrine and endocrine components that secrete digestive enzymes into the duodenum and hormones in blood.
- The endocrine portion secretes insulin, glucagon, and somatostatin that regulate blood glucose levels.

1) **Exocrine pancreas**

- **Pancreatic acini**: Are compound alveolar gland; the acinar cells secrete numerous digestive enzymes that breakdown proteins, carbohydrates, lipids, and nucleic acids.
- Cells show characteristic feature of protein secreting cells, with basal rER and apical secretory granules.

Duct system

- Ducts begin as Centroacinar cells located within the acini.
- Intercalated ducts are lined with simple cuboidal epithelium.
- Centroacinar cells and the cells lining of the intercalated ducts secrete bicarbonates to neutralize the acidity of the stomach contents (chyme) entering the duodenum.
- Striated ducts are not present.
- Interlobular ducts lead into one or more excretory ducts that empty into the duodenum.
- Secretion is regulated by cholecystokinin and secretin from enteroendocrine cells in the small intestine.

2) Endocrine pancreas (islets of Langerhans)

- Small clusters of cells, richly supplied by fenestrated capillaries, are scattered throughout the exocrine pancreas.

- They are easily recognized at LM as large pale areas between the acini.

Endocrine cells of the pancreas:

- Individual cell types cannot be distinguished with hematoxylin and eosin, but by immunohistochemistry.

a) A cells (alpha cells)

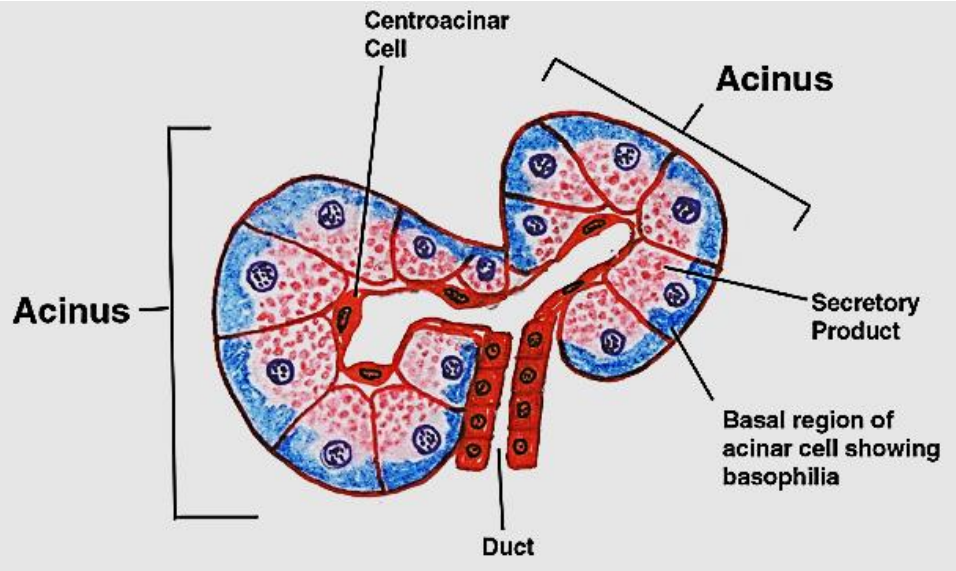
- Few cells located at the periphery of the islets.
- Secretes *glucagon*, which elevates glucose levels in the blood.

b) B cells (beta cells)

- Predominant cell type, small in size with basophilic cytoplasm.
- Secretes *insulin*, which lowers blood glucose levels.

c) D cells (delta cells)

- They are scattered among the alpha cells.
- Secretes *somatostatin*, which modulates release of the other two major hormones, glucagon and insulin.
- They also secrete *gastrin* which helps the secretion of gastric glands.



Exocrine pancreas

3) Liver

- The liver is the largest compound tubular gland of the body
- It occupies the upper part of the abdomen beneath the diaphragm.
- The liver contains both exocrine and endocrine components that secrete bile into the duodenum and plasma proteins in blood.

- ***Exocrine secretion (bile)*** is stored in the gall bladder and released into the duodenum. This secretory product contains bile acids that aid in the emulsification of lipids, bilirubin (the breakdown product of hemoglobin), phospholipids, and cholesterol.
- ***Endocrine function*** is the synthesis of plasma proteins, including albumin, clotting factors, and lipoproteins that are released into the liver sinusoids.
- ***Additional functions*** include the metabolization of digested food, storage of glucose as glycogen, and drug detoxification.

Structural Organization of the Liver

1) Connective tissue stroma:

- The liver covered by a thin coat of peritoneum (serosa), below which is a dense connective tissue layer, the fibrous capsule called *Glisson's* capsule.
- The capsule condensed in the hills, the *porta hepatis* that envelops the vessels, nerves and ducts.
- Trabeculae of connective tissue branches very extensively dividing the parenchyma of into the classic lobules.
- The amount of the interlobular connective tissue varies with the species.
- In the liver of pig and camel, the trabeculae are well developed.

2) Parenchyma

- The parenchyma of the liver is formed of organized plates of hepatocytes, one cell thick, and is separated by sinusoidal capillaries.

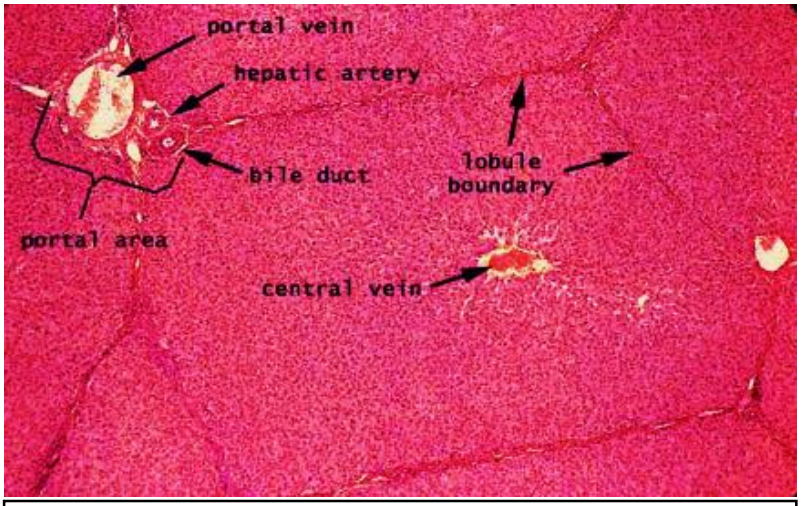
- Hepatic artery, portal vein and bile duct run in the ***portal area*** in the corners of the hexagonal classic hepatic lobules.
- *Sinusoidal capillaries (sinusoids)*, the vascular channels between the plates of hepatocytes.

Hepatocytes (liver cells)

The hepatocytes are arranged as branching plates that radiate from the central vein.

Histological structure of the hepatocytes:

- Cells are polyhedral in shape.
- Cells possess one or two nuclei.
- Cells contain abundant sER and rER, Golgi apparatus, mitochondria, and lysosomes. They contain large glycogen granules that stain strongly with PAS. Numerous peroxisomes, along with sER, carry out detoxification.
- At intervals between adjacent cells, the plasma membranes bulge inward to form a bile canaliculus, the beginning of the bile transport system.
- Microvilli project into the space of Disse, increasing surface area of the cells.



Histology of human liver

THE RESPIRATORY SYSTEM

By

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Respiratory System

The primary *function* of the respiratory system is to ***provide oxygen*** to, and ***remove carbon dioxide*** from, the circulating blood. To do that, the respiratory system must take in oxygen from the atmosphere and deliver it directly to the red blood cells. The red blood cells, or erythrocytes, course through the general circulation and exchange oxygen for carbon dioxide with each of the body's many trillions of cells. The respiratory system consists of *air conducting* portion and *respiratory* portion.

The air-conducting portion includes;

1. Nasal cavity
2. Nasopharynx
3. Larynx
4. Trachea
5. Bronchus
6. Bronchioles

The respiratory portion includes;

1. Respiratory bronchioles
2. Alveolar ducts
3. Alveolar sac
4. Alveoli

THE AIR-CONDUCTING PORTION

I. NASAL CAVITY

- The nasal cavity is subdivided into *vestibular*, *respiratory* and *olfactory* regions.

1. The vestibular region is lined by cutaneous mucous membrane (thin skin).

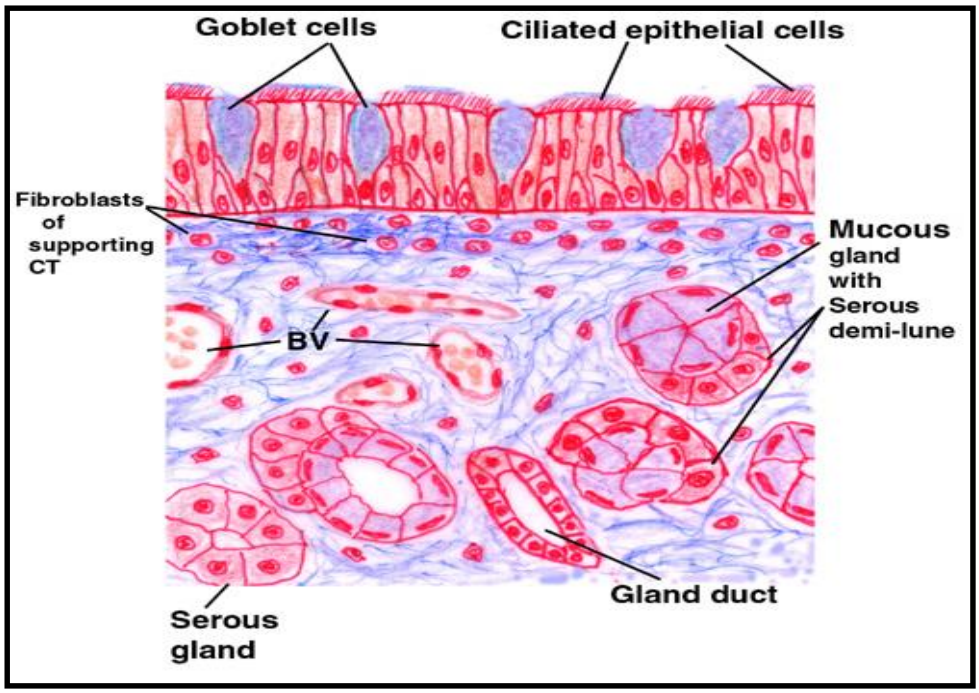
The lamina epithelialis is stratified squamous keratinized that rests on a connective tissue (C.T) propria-submucosa.

The propria-submucosa is a dense irregular CT containing seromucoid glands; dense capillary network, immunocompetent cells, short coarse hairs called *vibrissae*, sebaceous and sweat glands in some animals.

2. The respiratory region: is lined by *respiratory mucous membrane*.

The lamina epithelialis is pseudostratified columnar ciliated with goblet cells.

The propria-submucosa contains seromucoid glands, venous blood spaces as well as immunocompetent cells.

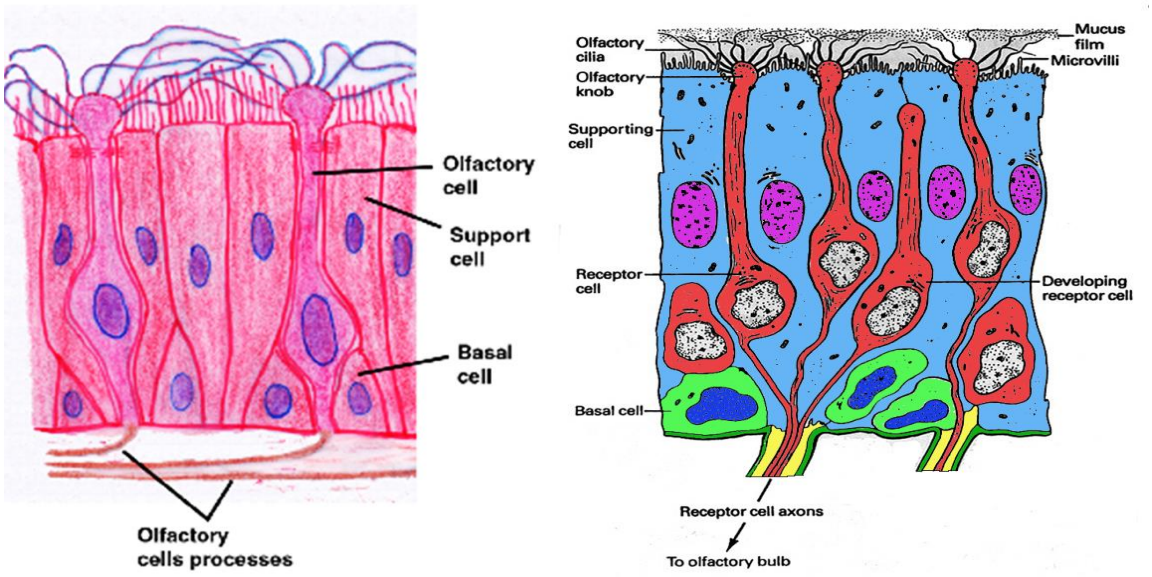


Respiratory Region

3. **The olfactory region:** is lined by *olfactory mucosa*. The olfactory mucosa is composed of olfactory epithelium, which is extremely tall, pseudostratified columnar in form and contains cells of three types: *olfactory receptor cells*, *supporting (sustentacular) cell*s and *basal cells*.

   - ***The olfactory cells*** are bipolar neurons, the cell bodies of which are located in the middle stratum of the olfactory epithelium.
   - ***The supporting or sustentacular cells*** are elongated cells with narrow bases. Their nuclei are oval lightly stained and located in the upper stratum of the olfactory epithelium. Their cytoplasm contains *yellow to brown pigments* that give a yellowish-brown color to the olfactory mucosa.
   - ***The basal cells*** they are small cells, may represent *stem cells*.

- The olfactory epithelium is supported by a vascular loose CT containing bundles of afferent nerve fibers and numerous serous glands (***Bowman glands***) which produce watery secretions in which odiferous substances are dissolved.



Olfactory Epithelium

Functions of nasal mucosa:

1. Air conduction.
2. Air conditioning (humidifies and warms inspired air).
3. Defense through the presence of immune cells.
4. Olfaction through the presence of olfactory cells.

II. Nasopharynx

- Its structure resembles those of the respiratory region of the nasal cavity.

The lamina epithelialis is of respiratory epithelium.

Lamina propria-submucosa composed of fibro-elastic and pharyngeal tonsil that is made up of group of lymphoid nodules and diffuse lymphatic tissues.

III. LARYNX

- The laryngeal wall is made up of *mucosa-submucosa*, *laryngeal cartilage*, *laryngeal muscles* and *adventitia*.

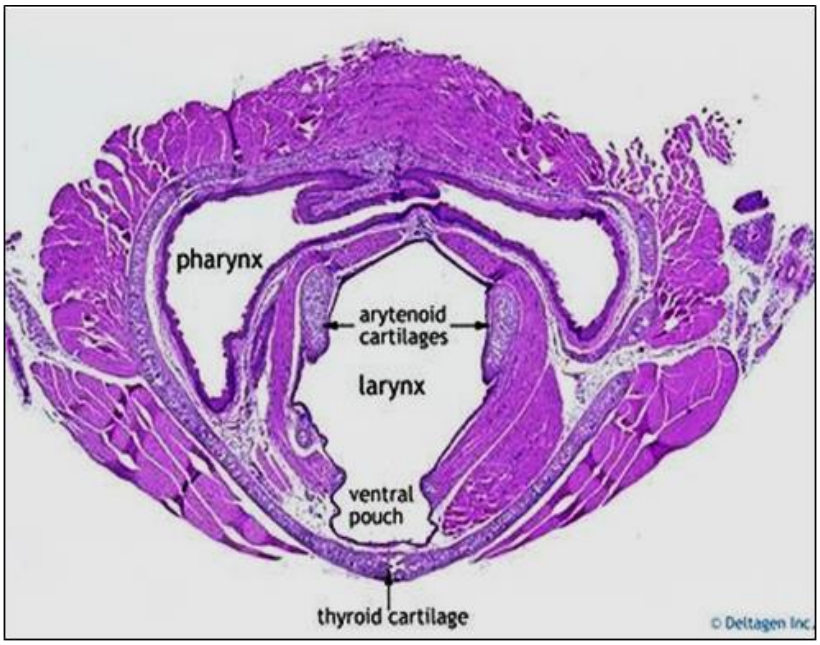
The lamina epithelialis composed of non-keratinized stratified squamous epithelium at the laryngeal vestibule, epiglottis and vocal folds. All the epithelia lining of the larynx below the vocal folds is of respiratory type.

The lamina propria-submucosa is formed of fibroelastic connective tissue containing seromucoid glands.

The laryngeal cartilages are represented by plates of hyaline and elastic types and are bounded together by connective tissue continues with that of the propria-submucosa.

The skeletal muscles are either intrinsic muscles that join the adjacent cartilage together or extrinsic muscles that originate in the extra-laryngeal structures and insert on the cartilage of the larynx.

The adventitia is a loose connective tissue that covers the larynx from outside.



The histology of the larynx

IV. TRACHEA

- The tracheal (and *extra pulmonary bronchi*) wall is formed of *mucosa-submucosa*, *tracheal cartilage*, loose connective tissue *adventitia* as well as dorsally seated *tracheal muscle*.

The lamina epithelialis is pseudostratified columnar ciliated with goblet cells.

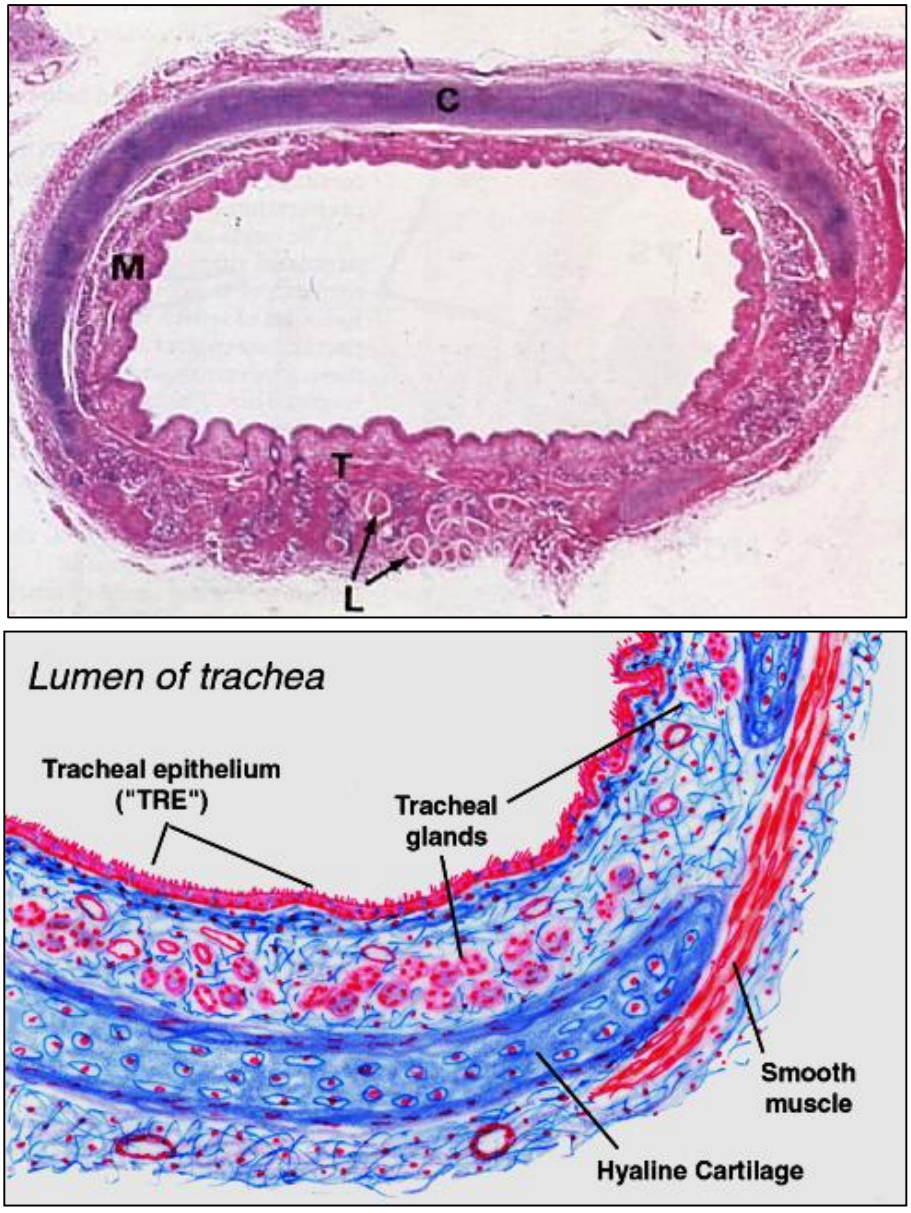
The lamina propria is formed of fibroelastic connective tissue with many immune cells, blood vessels, and nerves.

The submucosa is a loose connective tissue layer containing simple branched tubuloacinar seromucoid *tracheal glands*.

The tracheal cartilage is represented by a series of C-shaped rings of hyaline cartilage that help to prevent tracheal collapse during inspiration.

The transverse tracheal muscle is a smooth muscle band that extends transversely between the free ends of the cartilage rings.

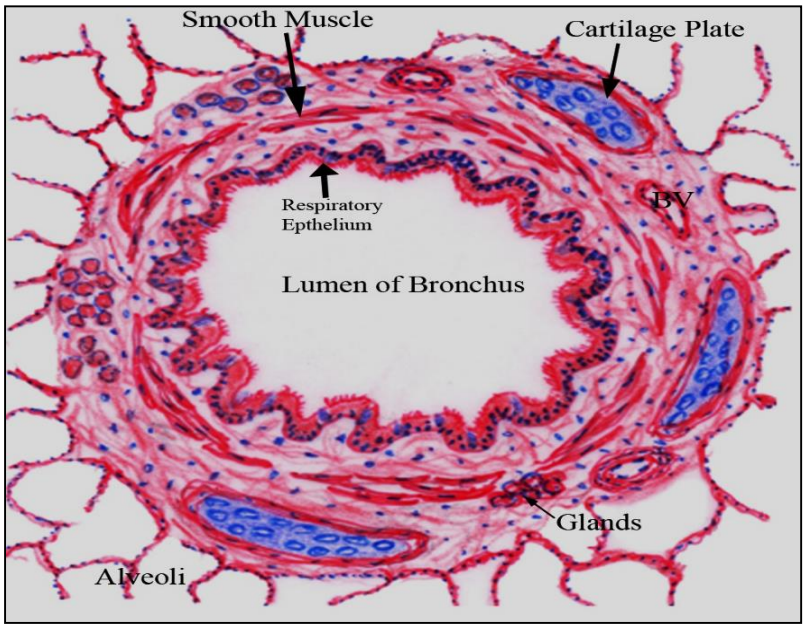
The adventitia is a loose connective tissue layer covers the external tracheal surface.



Transverse Section in Trachea

V. INTRAPULMONARY BRONCHI

- The basic structure of intra-pulmonary bronchus is *similar* to that of the trachea and extra-pulmonary bronchus, *but it differs in*:
  - The respiratory epithelium is less tall and contains fewer goblet cells.
  - The lamina propria is separated from the submucosa by a discontinuous layer of smooth muscle that becomes more prominent further down the tract.
  - The cartilage is arranged into *flattened, interconnected plates* rather than C-shaped rings.

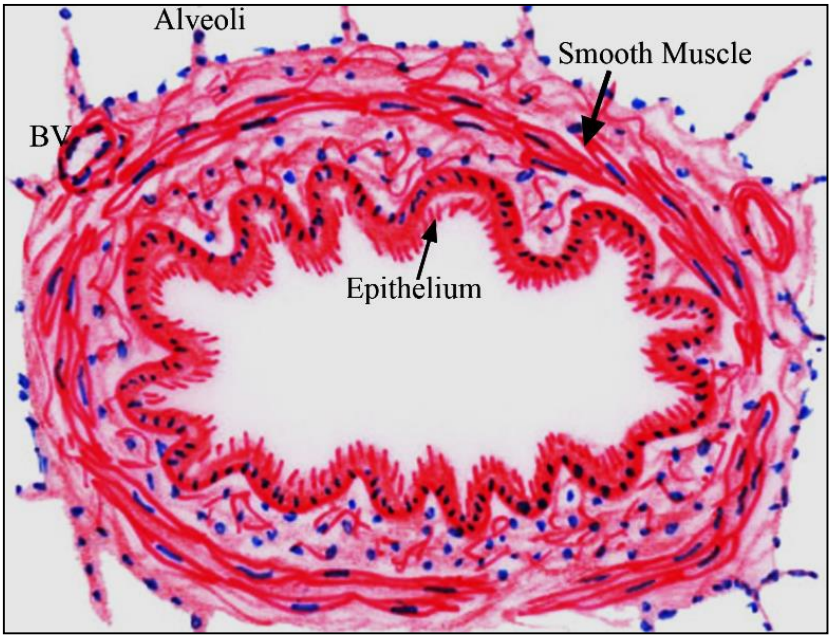


Intrapulmonary Bronchus

VI. BRONCHIOLES

- Bronchioles are airways of less than on millimeter in diameter and *have no* cartilaginous support.
- The epithelium is formed of *ciliated* and *non-ciliated* cells with few goblet cells.
- The non-ciliated bronchiolar cells (***Clara cells***) are columnar with a rounded apex that may project above the other cells and carry microvilli.

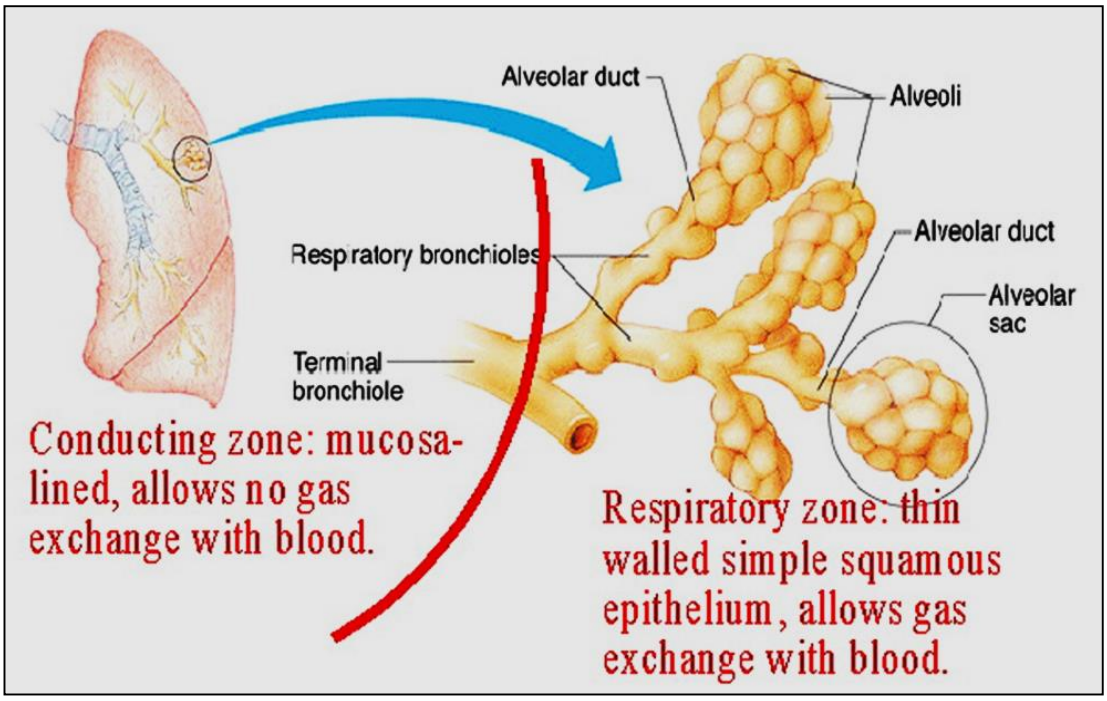
- The bronchiolar wall is characterized by *absence of cartilage*, *absence of glands* and the *smooth muscles form a continuous layer* and it relatively greater in amount than in bronchi.



The histology of Bronchiole

RESPIRATORY PORTION

- The respiratory portion comprises *respiratory bronchioles*, *alveolar ducts*, *alveolar sacs* and *alveoli*.


Alveolar duct
Alveoli
Respiratory bronchioles
Alveolar duct
Alveolar sac
Terminal bronchiole
Conducting zone: mucosa-lined, allows no gas exchange with blood.
Respiratory zone: thin walled simple squamous epithelium, allows gas exchange with blood.

1. RESPIRATORY BRONCHILOES

- The respiratory bronchioles resemble in its structure to terminal bronchioles except that their walls contains a small number of single alveoli.
- The epithelium of the respiratory bronchioles is devoid of goblet cells and consists of cuboidal ciliated cells and smaller number of non-ciliated Clara cells.
- Each respiratory bronchiole divides into several alveolar ducts.

2. ALVEOLAR DUCT AND ALVEOLAR SAC

- The alveolar duct is a duct like structure into which many alveoli open.
- The alveolar ducts lead to the alveolar sacs, which are sac like structure into which many alveoli open.

3. **PULMONARY ALVEOLI**

- The alveoli are pocket like structures, open at one side and lined by flattened epithelial cells, the alveolar epithelium as well as *alveolar macrophages*.
- The alveolar epithelium consists of cells of two types; squamous alveolar cells or *type I pneumocytes*, cuboidal alveolar cells or *type II pneumocyte*s.

a) Squamous Alveolar Cells (Pneumocyte type I)

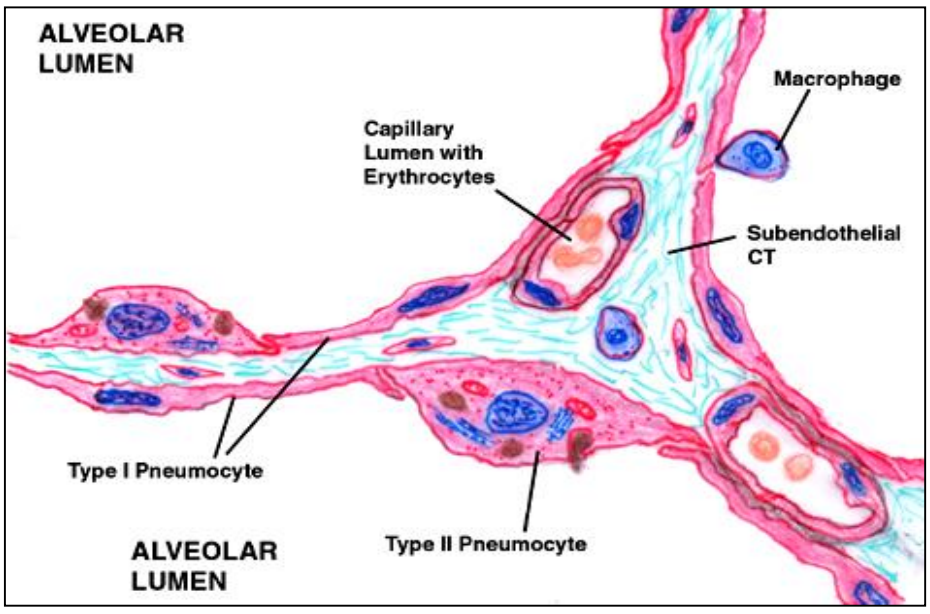
- They are squamous with flattened nuclei protrude slightly into the alveolar lumen.

b) Cuboidal Alveolar Cells (Pneumocyte type II)

- They are cuboidal and fewer in number than type I cells.

Functions:

- They are a reserve cell, which may as needed differentiate into new squamous cells to repair damage.
- They produce *surfactant*, a lipid rich material that coats the inside of the lungs and *reduces the surface tension* of the thin aqueous film that covers the cells.



Respiratory Portion and Alveoli Wal

THE ENDOCRINE SYSTEM

By

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Endocrine System

The endocrine system produces various secretions called hormones that serve as effectors to regulate the activities of various cells, tissues, and organs in the body.

- Its functions are essential in maintaining homeostasis and coordinating body growth and development and are similar to that of the nervous system.
- The endocrine system produces a slower and more prolonged response than the nervous system; both communicate to peripheral cells and organs.
- The control of the endocrine system is through hormones, which are carried to their destination via connective tissue spaces and the vascular system.

Types of hormonal control:

1. Endocrine control

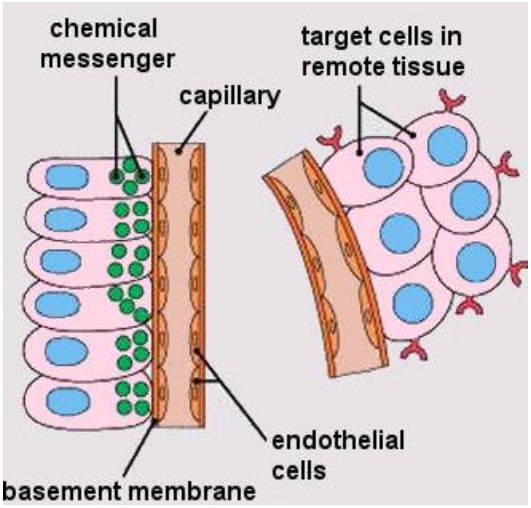
- The hormone is discharged from a cell into the bloodstream and is transported to the effector cells.

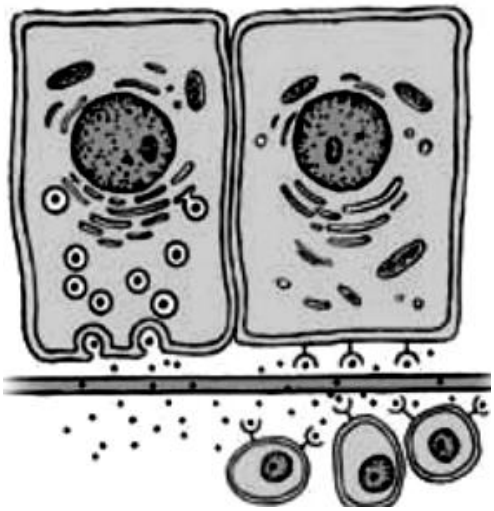
2. Paracrine control

- The hormone is secreted from one cell and discharged to the intercellular spaces to acts on adjacent cells that express specific receptors.

3. Autocrine control

- The hormone responds to the receptors located on the cell that produces it.





Endocrine and paracrine hormonal controls

General features of the endocrine glands:

- The endocrine glands are not connected to the surface; possess no ducts, called ductless glands.
- Parenchymal cells are usually arranged in plates, cords, clusters of cells or follicles to maximize surface contact with blood vessels.
- They release their products, called hormones, into the extracellular space which can affect adjacent cells (paracrine secretion) or diffuse into capillaries to be transported in the blood (endocrine secretion).
- Hormones act only on selected cells, called target cells, which express specific receptors to mediate the hormone signal.
- The endocrine system consists of organs (pituitary, thyroid, parathyroid, adrenal and pineal glands), clusters of cells (pancreatic islets of Langerhans, theca interna in the ovary and interstitial cells in the testis) and individual cells (enteroendocrine cells in the digestive tract).
- Endocrine cells and organs have diverse structures, functions and embryological origins. Their hormones can be steroids (cortisol, testosterone),

amino acid derivatives (thyroxin, epinephrine) or peptides and proteins (insulin, growth hormone).

- Endocrine organs are highly vascular and most have fenestrated capillaries which facilitate the entry of the hormone into the blood stream.
- Together, the nervous and endocrine systems coordinate functions of all body systems and are functionally integrated as the neuroendocrine system.
- Nervous actions involve the secretion of neurotransmitter substances over short distances, to obtained rapid and localized effect; while hormones often work at a distance, to obtain slower and more diffuse response.

Basic organization of the endocrine glands:

- **Stroma** (*connective tissue element*)

- The endocrine glands are covered by a capsule of collagenous fibers.
- Trabeculae extend into the glands, they form reticular fibers network, which hold the glandular epithelium and blood vessels to the glands.

- **Parenchyma** (*epithelial element*)

- Endocrine cells are arranged as irregular cords, clumps or hollow follicles, and the cells are polyhedral in shape. Fenestrated blood capillaries or sinusoids are in direct contact with the secretory cells.
- The ultrastructure of the secretory cells depends on the type of secretion. RER is predominant in cells which secrete protein hormones, while sER is found in the cells that secrete steroid hormones.

Pituitary gland *(Hypophysis Cerebri)*

- This small oval gland is attached to the base of the brain by the infundibulum and protected inside sella turcica (Turkish saddle) in the sphenoid bone.
- The hypophysis was considered the master endocrine gland because its secretion controls other endocrine glands. However, the pituitary gland itself is under the control of the hypothalamus.
- It has two major divisions, adenohypophysis and the neurohypophysis, that differ in embryonic origin as well as structure and function.

Terminology based on embryonic origin	Pituitary subdivisions	Clinical terminology
Adenohypophysis	Pars distalis	Anterior lobe of pituitary
	Pars tuberalis	
	Pars intermedia	
Neurohypophysis	Pars nervousa	Posterior lobe of pituitary
	Infundibulum	

Embryonic development of the pituitary gland:

- The pituitary gland has a double embryonic origin.
- The adenohypophysis is derived from an evagination of the ectoderm of the oropharynx toward the brain (Rathke's pouch).
- It contacts with developing neurohypophysis and then become disconnected from its origins.
- The neurohypophysis is derived from neural ectoderm as downgrowth of the floor of the third ventricle (the diencephalon) without disconnection from the brain.

- The remnant of Rathke's pouch forms residual cleft (Rathke's cleft) which separates the pars distalis from pars intermedia.
- This development results in intimate neural and vascular relationships between the hypothalamus and hypophysis.

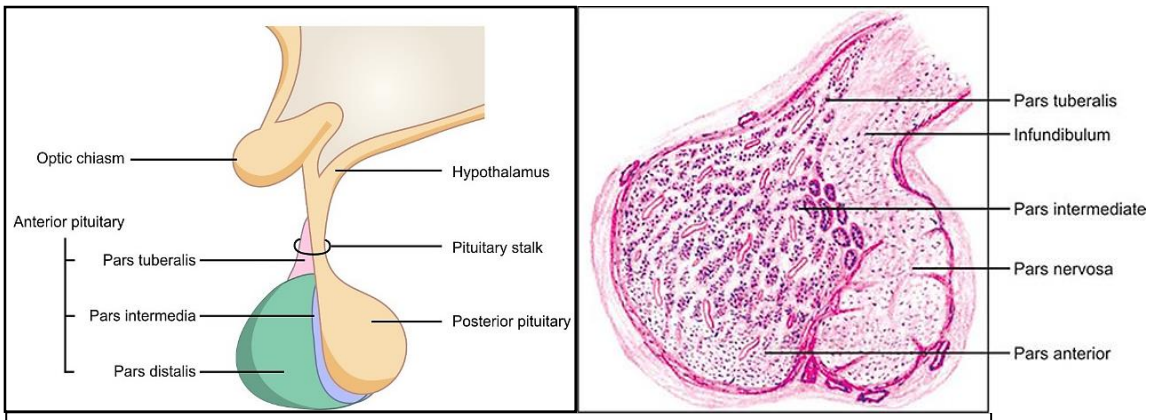
Histology of the pituitary gland:

- **Stroma:**

- The pituitary gland covered with two capsules, the outer one is derived from the dura matter that invests the gland completely except at the infundibulum. The inner connective tissue capsule from which delicate trabeculae of collagenous and reticular fibers penetrate into the gland.

- **Parenchyma:**

- The parenchyma of the pituitary gland is formed by two major divisions the anterior lobe (adenohypophysis) and the posterior lobe (neurohypophysis).



The anatomical and histological structure of the pituitary gland

A. Anterior lobe of the pituitary gland

(*Adenohypophysis*)

1) Pars distalis

- The cells of pars distalis are differentiated according the staining affinity:

a. Chromophobes

- They are poorly stained and appear pale.
- They are about 50% of epithelial cells. The cytoplasm has sparse granule.
- Chromophobes are actually a reserve (stem-like) for degenerated chromophils cells or may be degranulated cells.

b. Chromophils

- They are deeply stained granulated cells.
- They made up about 50% of the glandular cells.
- According to the staining and function they are either acidophils or basophils.

I. Acidophils (*Alpha cells*):

- They are small in size and great in numbers (about 40 %).
- Acidophils stain pink with acidic dyes, e.g., eosin or orange G. They give PAS negative reaction (no carbohydrates).
- The cytoplasm of the acidophils contains many rER, mitochondria and Golgi apparatus. Secretory granules are scattered in the cytoplasm.

Types of acidophils:

1) **Somatotropes (GH cells)**.

- Secretion — Growth hormone (somatotropin).
- Target organs — Skeletal system (cartilage & bone) and cells.
- Action — Promotes cell growth, protein synthesis, lipid and carbohydrate metabolism.

- Somatotropes (GH cells) are most commonly found within the pars distalis and constitute approximately 50% of the parenchymal cells in the anterior lobe of the pituitary gland.
- These large-sized, oval cells exhibit round, centrally located nuclei; the cytoplasm is characterized by presence of coarse acidophilic granules.

2) Mammotropes (PRL cells)

- Secretion — Lactogenic hormone (prolactin; PRL). .
- Target organs — Acini of the mammary glands (during pregnancy and lactation)
- Action — Stimuli milk secretion.

- The cells are small in size and elongated oval in shape with round, eccentrally located nuclei.
- Secretion of PRL is under inhibitory control by dopamine, the catecholamine produced by the hypothalamus. However, thyrotropin-releasing hormone (TRH) and vasoactive inhibitory peptide (VIP) are known to stimulate synthesis and secretion of PRL.

II. Basophils (*Beta cells*):

- They are large in size and few in numbers (about 10 %).
- Basophils contain basophilic granules, which stain with basic dyes, e.g., hematoxylin and methylene blue. They give PAS positive reaction (glycoprotein).
- The basophils are includes; thyrotropes (TSH cells), gonadotropes (FSH and LH cells) and corticotropes (ACTH cells).

Types of basophils:

1) **Thyrotropes (TSH cells)**:

- Secretion — Thyroid stimulating hormone (TSH).
- Target organs — Thyroid follicular cells.
- Action — Stimulates thyroid hormone secretion which increase metabolic rate.

- These large, polygonal cells with round and eccentric nuclei; they exhibit cytoplasmic basophilia and stain positively with PAS reagent.

2) **Gonadotropes (FSH, LH or ICSH):**

- Secretion — a. Follicular stimulating h. (FSH)
  b. Luteinizing hormone (LH)
  c. Interstitial cells stimulating h. (ICSH)
- Target organs — a. Ovarian follicles
  b. Corpus luteum in ovaries
  c. Interstitial cells of Leydig in testis
- Action — Promotes cell growth and maturation of the target cells

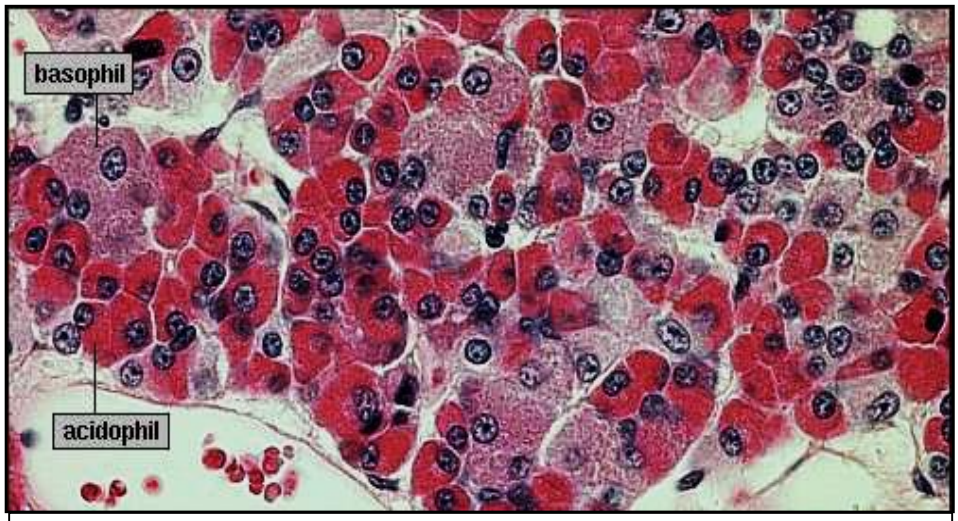
- These small, oval cells with round and eccentric nuclei produce LH, ICSH and FSH. They are scattered throughout the pars distalis and stain intensely with both basic stains and PAS reagent.

3) **Corticotropes (ACTH cells):**

- Secretion — Adrenocorticotropic hormone (ACTH).
- Target organs — Adrenal cortex cells.
- Action — Stimulates the secretion of cortisol and corticosterone.

- ACTH cells are polygonal, medium-sized with round and eccentric nuclei.

- ACTH release is regulated by corticotropin-releasing hormone (CRH) produced by the hypothalamus.



The acidophils and the basophils of the adenohypophysis

B. Posterior lobe of the pituitary gland

(*Neurohypophysis*)

- It is consisting of the pars nervosa and the infundibulum and the median eminence that connects it to the hypothalamus.
- The neurohypophysis contains nerve fibers, supportive cells, blood capillaries and accumulation of secretions. It has no secretory cells and no nerve cells.
- The neurohypophysis is not an endocrine gland; rather, it is a storage site for neurosecretions of the neurons of the supraoptic and paraventricular nuclei of the hypothalamus.

1) Pars nervousa

- **Stroma.** The pars nervousa is surrounded by connective tissue capsule containing blood vessels.
- **Parenchyma.**

- The pars nervosa, the neural lobe of the pituitary, contains:
  a) Non-myelinated nerve fibers.

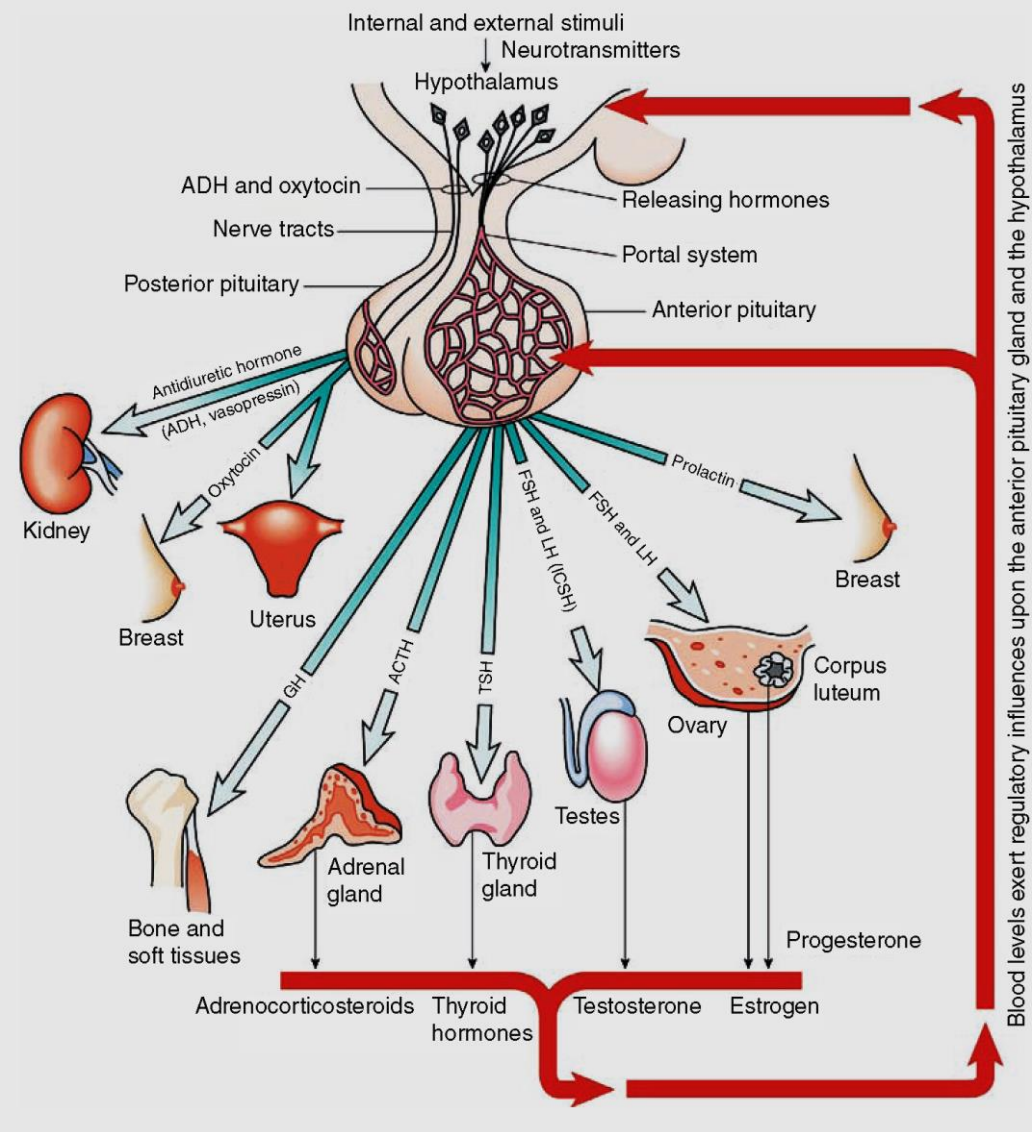
- They are the axons of neurosecretory neurons whose cell bodies lie in the **supraoptic** and **paraventricular** nuclei of the hypothalamus.

b) Herring bodies.

- Expanded axon terminals which accumulate secretory granules containing oxytocin or antidiuretic hormone (vasopressin).

c) Pituicytes.

- They are nonsecretory supportive neuroglia-like cells.
- They are small cells with branching processes form an extensive fibrous network among the axons and capillaries bed in pars nervousa.



Hormones of the pituitary gland and hypothalamus regulation

Thyroid gland

- Thyroid gland is located in the neck anterior to the larynx and consists of two lobes of glandular tissue connected by isthmus.
- It is derived mainly from endoderm.

- **Stroma**

- It is covered by two capsules; the outer one originates from the deep cervical fasciae. The inner one is true thin capsule of dense irregular connective tissue.
- Fine fibrous septa penetrate the glands dividing it into lobules and fine reticular fibers form the stroma of the gland.
- The septa provide support; carry sinusoidal capillaries, lymphatics and nerves to the gland.

- **Parenchyma**

- The thyroid gland consists of two unique structural and functional subdivisions, the thyroid follicles and the parafollicular cells.

1. **Thyroid follicles**

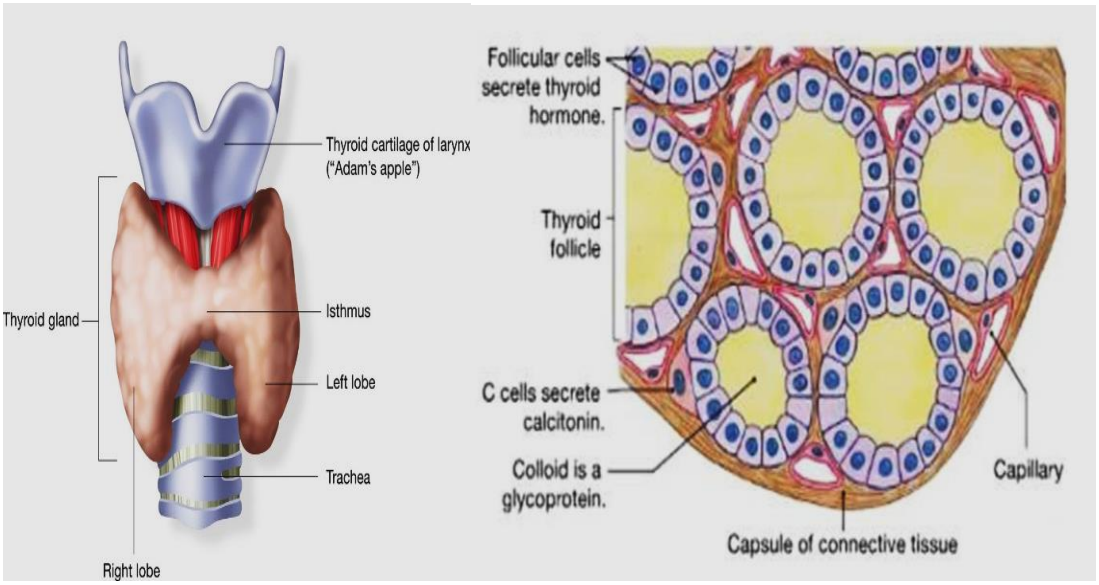
- Spheres composed of a single layer of follicle cells; they are simple cuboidal cells with centrally, round nuclei; resting on a basement membrane.
- The follicles have a cavity, the follicular cavity, usually contains a gel-like substance called the colloid.
- The follicular structure reflects the physiological condition of the gland. In hyperactive follicles they are simple columnar, while if the gland is inactive the follicular cells are simple squamous.
- Thyroid follicular cells show the ultrastructural feature of the protein secreting cells. The cytoplasm is rich in the rER, distended saccules of Golgi apparatus, apical secretory granules, mitochondria, lysosomes and residual bodies.
- The apical surface has few short microvilli that in contact with the colloid.
- Follicle cells secrete *thyroglobulin*, a glycoprotein that is stored in the center of the follicle.

- Thyroglobulin contains modified tyrosine amino acids that constitute the thyroid hormones, *thyroxin (tetraiodothyronine, T4)* and *triiodothyronine (T3)*. Follicle cells take up the stored thyroglobulin and release the hormones into the blood stream.

The thyroid follicular cells:

- Secretion — Thyroid hormone (T3 and T4)
- Target organs — all tissues and organs.
- Action — 1. Regulate the basal metabolic rate.
  2. Maintain growth of cells.
  3. Thermoregulation.
  4. Maintain normal gonadal development.

- The activity of the thyroid gland is controlled by the thyroid stimulating hormone (TSH) secreted by the thyrotropes in pars distalis of the pituitary as well as the thyroid releasing hormone (TRH) from the hypothalamus.



The anatomical and histological structure of the thyroid gland

2. **Parafollicular cells** ***(C cells, clear cells)***

- Occur within the follicular epithelium rested on the basement membrane, but they are separated from the lumen by the follicular cells.
- They are derived from the neural crest (ectoderm in origin).
- Possess secretory granules containing the hormone calcitonin, which acts to inhibit bone resorption, lowering calcium levels.
- Belong to the diffuse neuroendocrine system (DNES).

The parafollicular or C-cells:

- Secretion — Calcitonin hormone
- Target organs — Osteoclast of the bone.
- Action — 1. Lowering the blood calcium level.
  2. Suppressing bone resorption.
  3. Increases osteogenesis processes.

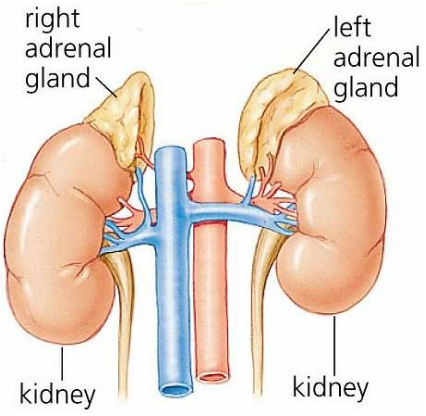
Adrenal (Suprarenal) glands

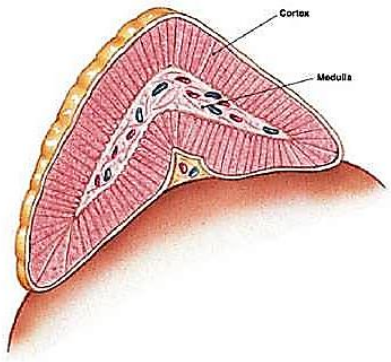
Paired glands, each located at the superior pole of a kidney; consist of two distinct subdivisions with different embryological origins; the cortex and medulla.

- ***The adrenal cortex***. Derived from mesoderm and constitutes the major steroid producing gland.
- ***The adrenal medulla***. Derived from neural crest and is a major source of epinephrine and norepinephrine neurohormones.

- **Stroma**: the adrenal gland is surrounded by a thick capsule formed of dense collagenous bundles with fine elastic and reticular fibers as well as fibroblasts.
- Trabeculae arising from the capsule bearing the same structure of the capsule penetrating the gland and form the stromal network of reticular fibers and carry wide fenestrated capillaries inbetween the cords of parenchymal cells.

- **The parenchyma**: The parenchyma of the glands is differentiated into cortex and medulla.





The morphological structure of the adrenal (suprarenal) glands

1. The adrenal cortex

- It is formed of cell cords which extend from under the capsule until the medulla.
- These cell cords are separate by connective tissue septal and the fenestrated blood capillaries extended in parallel to them.
- The ultrastructure of the cells of the adrenal cortex showing the features of steroid-secreting cells:
    - Abundant smooth endoplasmic reticulum
    - Mitochondria with tubular cristae in the zona fasciculata and the zona reticularis; shelf-like cristae in the zona glomerulosa.
    - Numerous lipid droplets filled with cholesterol, precursor for steroid hormones.
    - Secretion is by diffusion, with no hormone storage.

- The adrenal cortex is subdivided into three zones; however they are not sharply demarcated from each other; the outermost *zona glomerulosa*, the middle *zona fasiculata* and the inner *zona reticularis*.

a) <u>Zona glomerulosa</u>

- Located immediately beneath the capsule where all the cords are more or less convoluted forming a round clusters, ovoid masses of cell (glomerulus).
- In horse the cells arranged in arched form thus the name *zona arcuata*.
- The cells are columnar or pyramidal is shape with dark stained oval nuclei.
- The cytoplasm contains basophilic granules and lipid droplets.
- The cells of zona glomerulosa secrete *<u>mineralocorticoids</u>* (e.g., aldosterone).

b) <u>Zona fasciculata</u>

- Middle layer, largest cortical zone
- Cells arranged in rows, each of two cells thickness, perpendicular to the capsule with alternating sinusoidal capillaries.
- They are polyhedral in shape with large central nuclei and the cytoplasm filled with lipid droplets (steroid secreting cells).
- During histological preparation the lipid dissolved and the cells appear vacuolated like sponge so the name spongiocytes.
- It secretes *<u>glucocorticoids</u>* (e.g., cortisone) and *androgens.*

c) <u>Zona reticularis</u>

- Occupies deepest layer of the cortex
- Cells arranged as anastomosing cords with sinusoidal capillaries inbetween.
- Same secretions as zona fasciculata, *glucocorticoids* and *<u>androgens</u>.*

2. Adrenal Medulla

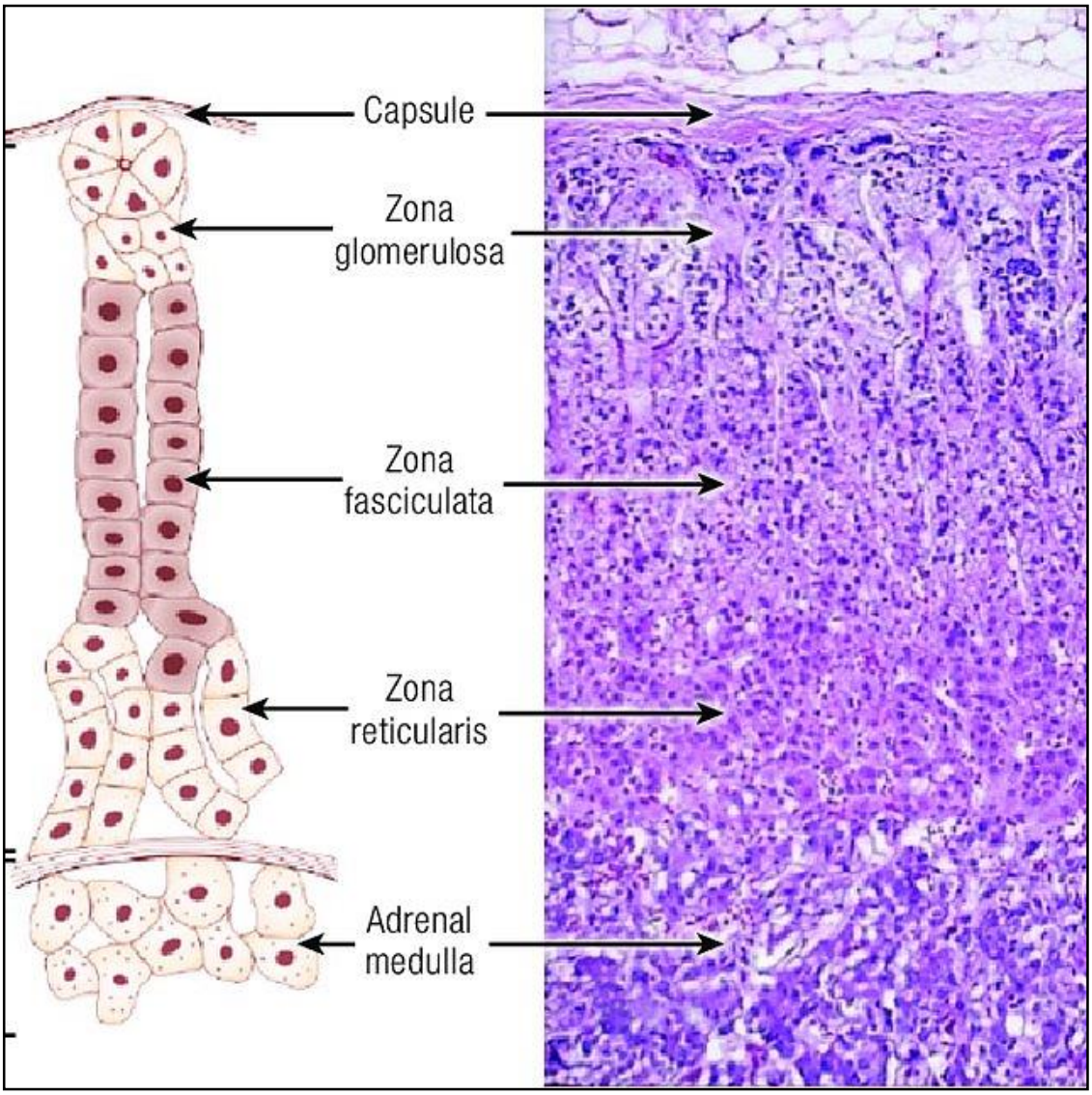
- The adrenal medulla is located in the center of the adrenal gland.
- It derives from embryonic neural crest (ectoderm).
- The adrenal medulla consists of anastomosing cords of secretory cells, grouped around the blood vessels and fenestrated capillaries.

a) <u>Chromaffin cells</u>

- They are sympathetic like ganglion cells, without axons or dendrites.
- The cells are large polyhedral with large nuclei and the cytoplasm is basophilic with strong affinity for chromium salts, called chromaffin cells.
- It contains abundant dense-core, secretory granules. These granules are filled with catecholamine.
- Chromaffin cells synthesize and release epinephrine and norepinephrine.

b) <u>Ganglion cells</u>

- Few sympathetic (and may be parasympathetic) ganglion cells may occur singly or in clusters among the chromaffin cells, in the adrenal medulla.


Capsule
Zona glomerulosa
Zona fasciculata
Zona reticularis
Adrenal medulla

IMMUNE SYSTEM

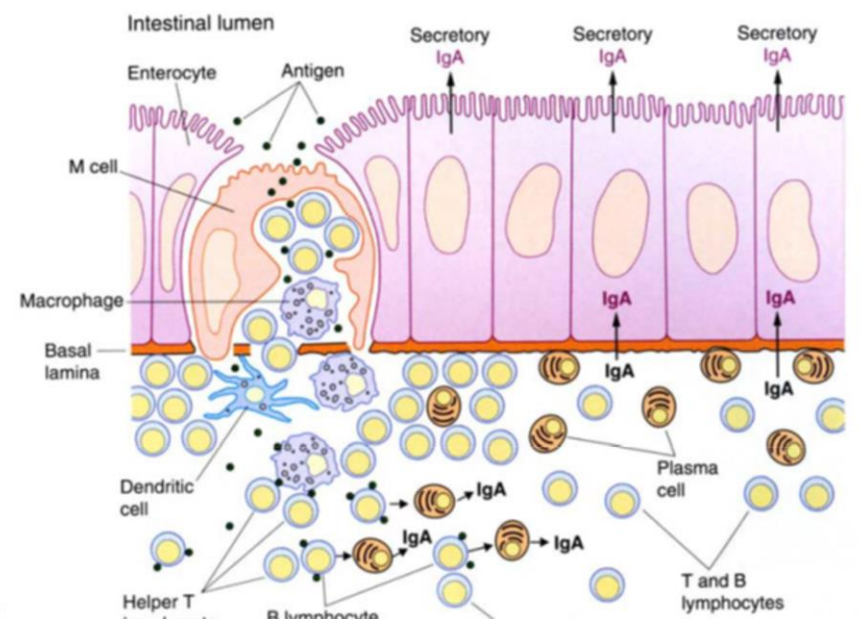
Prof. Dr. / Saad Emara

IMMUNE SYSTEM

- The immune system is responsible for self-recognition and helps defend the body against diseases by producing immunocompetent lymphocytes. The immune system protects the body from invasion and damage by foreign (non-self) materials.
- The immune system is formed from cells, organs and complement components.

(1) Cells:-

- [a] ***Lymphocytes***, white blood cells that are produced in lymphatic organs by a process called lymphopoiesis, interact with *macrophages* and other *antigen-presenting cells* to initiate an immune response.
- [b] ***Macrophages*** are derived from monocytes that have left the blood and entered the tissue. Macrophages phagocytose antigens, process them, and present an *epitope* (i.e.an antigenic fragment of the antigen). Monocytes and macrophages secrete monokines (*cytokines*, are soluble secretions affect other cells), such as *interleukin* 1 (IL-1). IL-1 of macrophages stimulates lymphocytes to produce lymphokines, which affect immune responses and the inflammatory process.
- [c] ***Antigen presenting cells***, capture whole antigens and hold them on their surfaces for extended periods.
- These cells as *follicular dendritic cells* in nodules of lymph nodes, *Langerhans cells* in the epidermis and M-cell in intestines.



(2) **Organs** :-

- ***Primary lymphatic organs***, that produce immunocompetent T-lymphocytes and B-lymphocytes. These organs include *bone marrow, the thymus, cloacal bursa* in birds and certain gut associated lymphatic tissue (*GALT*) in some mammals. The lymphocytes produced by primary lymphatic organs are carried in the blood to the secondary lymphatic organs, where they complete their differentiation.
- ***Secondary lymphatic organs*** which are organized for immune response. They can monitor the tissue fluid of mucous membrane, the lymph draining from various body parts and the blood.
- The secondary lymphatic organs include *mucous associated lymphatic tissue (MALT), lymph nodes, spleen* and *hemal nodes.*

(3) **Complement components: -**

- The Complement system is a group of immunologically active blood proteins, called complement components, that are activated in a series of steps initiated by an antigen-antibody reaction or by foreign molecules.
- The complement system plays a significant role in host defense and the inflammation process. Specific function include: -

1- Lysing of cells and bacteria.

2- Inducing degranulation of mast cells and basophils.

3- Attracting neutrophils.

4- Enhancing phagocytosis.

- A complex cellular interaction between lymphocytes, macrophages, granulocytes, mast cells and antigen presenting cells lead to immune responses. All these cells are called ***immunocompetent cells***. These cells have the capacity to distinguish self from non-self and to provide the inactivation or destruction of the foreign materials. Such interactions take place mainly in lympho-myeloid complex (lymphoid organs) that form the immune system.

Immune response

- The immune response is highly specific recognition of substances or cells as self or non-self. Recognition of a foreign antigen or its cellular source causes a response that is directed toward elimination of the antigen or its source.
- *Antigens* are foreign substances (proteins or polysaccharides) that cause response when they contact cells of the immune system. The immune system recognizes antigens by means of unique combinations of short sequences of amino acids (*epitopes*).
- The response leads to activation, that causes lymphocytes to enlarge and become basophilic, repeated mitotic division produces many enlarged cells with the same specificity as the activated cells. The activated cells differentiate into effector cells and memory cells. Two types of immune responses produce two types of immunity :- antibody- mediated (*humoral*) immune response and *cell-mediated* immune response.

I- Humoral immunity :-

- Humoral immunity or antibody-mediated immunity occurs in response to bacteria that live outside cells of the host and/or to toxins released by these

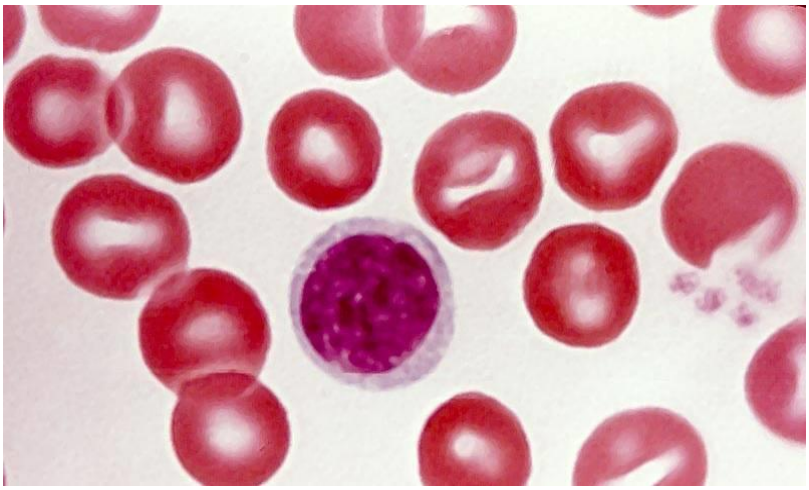
bacteria. Antibodies circulate glycoproteins (immunoglobulins) that are produced by B-lymphocytes and bind to specific antigens.

II- Cell mediated immunity :-

- The cell mediated immunity is against specific antigens.
- The cell mediated immune responses are initiated by microorganisms that enter the cells of the host, products released by such microorganisms, viruses, fungi, grafted tissue and certain substances that contact the skin. Cells of malignant tumors also initiate a cell mediated immune response.
- The cell mediated immune response is a function of T-lymphocytes.

LYMPHOCYTES

- The lymphocytes circulate between the blood and connective tissue and lymphatic organs.
- The lymphocytes are all similar in appearance. They have a spherical to ovoid heterochromatic nuclei surrounded by a small amount of moderately basophilic cytoplasm.
- There are three types of lymphocytes according to their specific functions and distinctive cytochemical markers: *B- lymphocytes, T- lymphocytes* and *natural killer* or *Null cells* (NK).



1- **B- lymphocytes (*B-cells*)** :-

- B- lymphocytes (Bursa-dependent lymphocytes) are developed from bone marrow stem cells then migrate to cloacal bursa in birds or bursal equivalent in mammals, a central component of lymphoid complex, where they undergo differentiation and become mature programmed B-cells.
- B- lymphocytes and their derivatives, plasma cells are responsible for humoral immunity.
- *Activation* of B- lymphocytes occurs in response to the antigen for which B-lymphocytes are specific.
- Activation usually requires interaction with an activated T-helper lymphocyte with the same specificity and macrophages or other antigen-presenting cells (or cytokines produced by these cells).
- Activated B- lymphocytes undergo clonal expansion and differentiate to : -

*[1] *Plasma cells* that are fully differentiated B-cells. They are highly specialized for production of a specific antibody.

*[2] *B-memory cells* are B-cells that have stopped at an intermediate stage of clonal expansion and development. They are primed to respond strongly and rapidly to differentiate upon subsequent exposure to the antigen.

2- **T- lymphocytes (T-cells) :-**

- T- lymphocytes (thymus-dependent lymphocytes) are developed from bone marrow stem cells that migrate to the thymus where they differentiate and become mature programmed T- lymphocytes.
- T- lymphocytes are the most numerous lymphocytes in the blood. They are responsible for cell-mediated immunity
- Activation of T-cells occurs when a specific antigen is presented to the T-cells by macrophage or another antigen presenting cell.

- Activated T- lymphocytes undergo clonal expansion and differentiate to cytotoxic (killer) T-cells, memory T-cells, T-helper cells and T-suppressor cells.
- *Cytotoxic* (killer) *T-cells* kill infected, foreign or abnormal cells. They are responsible for graft rejection.
- *Memory T-cells* have not completed their differentiation. If they are exposed to the same antigen they respond quickly and are more vigorous than the initial response.
- *T-helper cells* help activate other lymphocytes by direct interaction or by releasing lymphokines that promote conversion of B-cells to plasma cells and enhance other immune responses.
- *T-suppressor cells* inhibit B-cells formation and suppress other immune responses.

3- **Null cells(NK*) :-***

- Natural killer cells are cytotoxic. Malignant cells are their usual target.

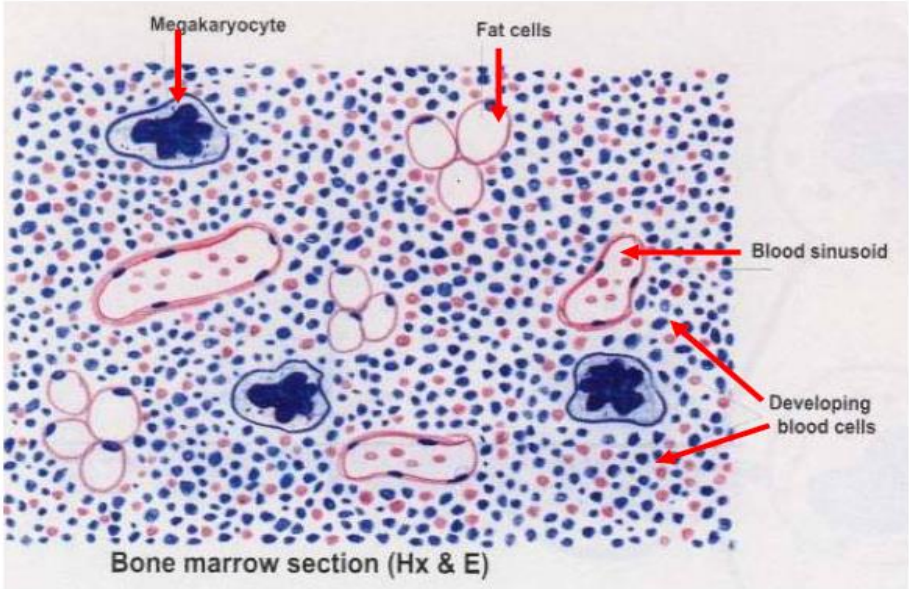
Primary lymphatic organs

- The primary or central lymphatic organs include the bone marrow, the thymus and the cloacal bursa in birds or bursa equivalent (as GALT in some mammals).

BONE MARROW

- Bone marrow is classified as red or yellow marrow.
- The red marrow is active in hemopoiesis during post-natal life.
- The yellow marrow contains large amount of fat
- The red bone marrow considered as a center for most immunocompetent cells and the lymphoid organ for

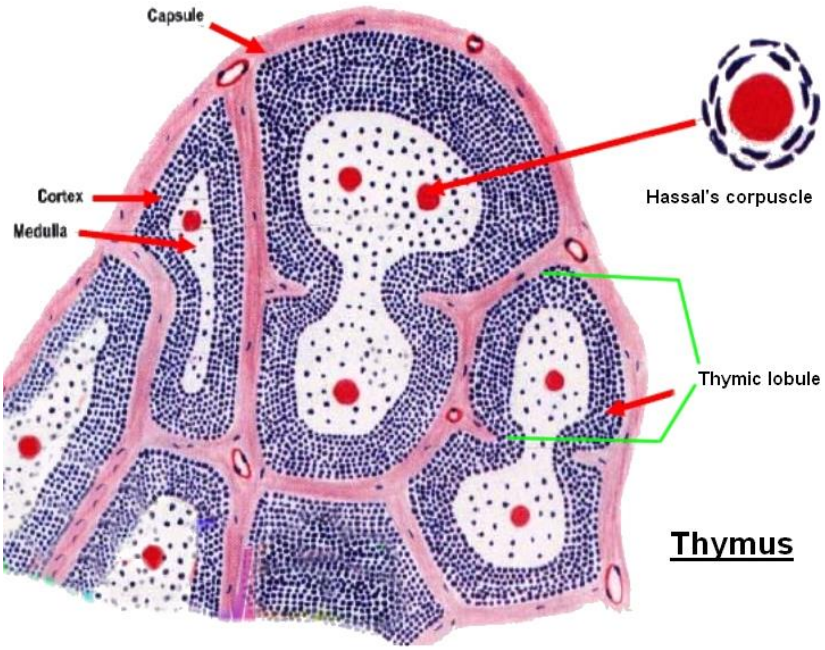
- The red bone marrow is formed from stroma, parenchyma and blood sinusoids.
- The stroma is reticular tissue. Reticular fibers, reticular cells and macrophages and some collagen fibers around the blood vessels.
- The parenchyma comprises stem cells, granulocytes, agranulocytes, red blood cells and megakaryocytes as well as the intermediate stages of development between these cells and the stem cells.
- The blood sinuses are the blood vessels of the bone marrow.



Bone marrow section (Hx & E)

THE THYMUS

- The thymus is bilobed lymphatic (lymphoepithelial) organ presents in the thoracic inlet.
- The thymus is the only lymphatic organ that is lobulated. After puberty, it involutes, becoming smaller in size, the parenchyma is replaced by fat cells.



Thymus

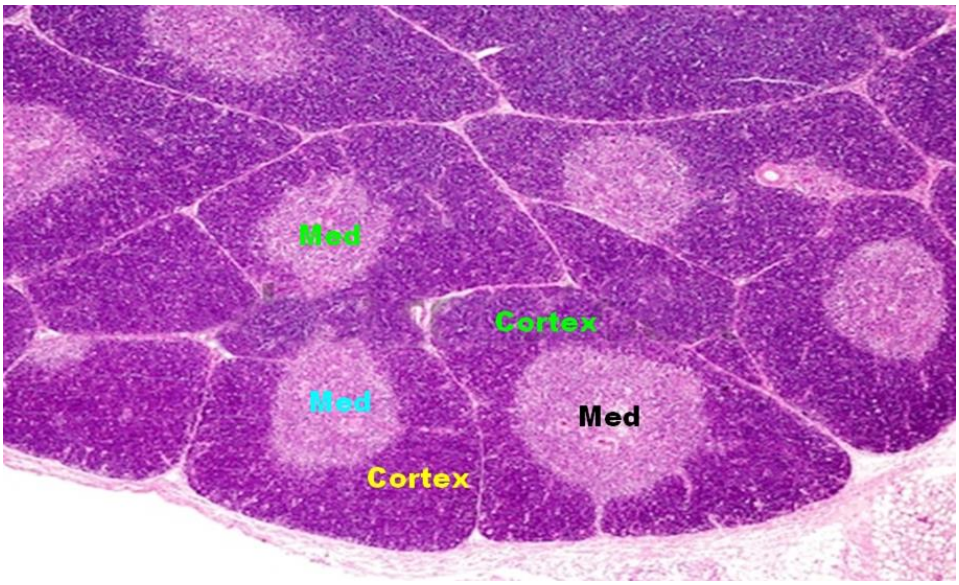
Stroma of the thymus :-

- (1) Each lobe of the thymus is covered by a thin loose connective tissue capsule. The capsule gives a thin connective tissue septum that divides the lobe into incomplete lobules.
- (2) Epithelial cells form a continuous sheet that separates the parenchyma from the connective tissue of the capsule and septa as well as perivascular tissue within the organ.
- (3) Epithelial reticular cells form the stroma within the cortex and medulla. Their long slender processes are joined by desmosomes, forming three-dimensional networks that are structurally similar to that of reticular connective tissue but without reticular fibers. Epithelial reticular cells secrete hormone-like substances and contain secretory granules

- (4) Thymic corpuscles are acidophilic bodies formed from the epithelial reticular cells in the medulla. They are composed of connective layers of squamous cells, the central layer degenerates and fills with keratohyalin granules.

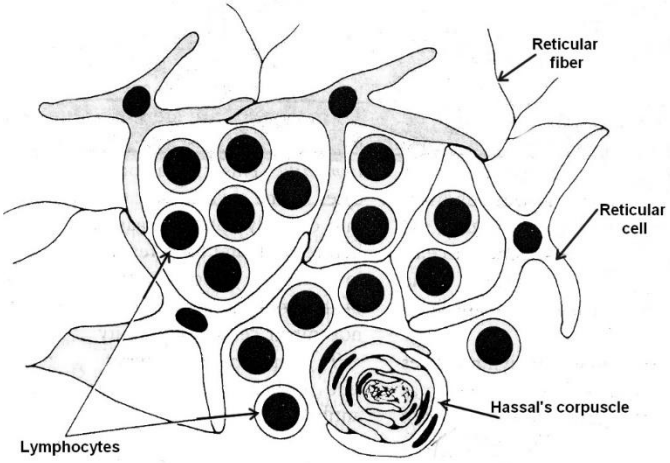
Parenchyma..

- Each thymic lobule has an outer cortex and an inner medulla, but because the division into lobules is incomplete, both cortex and medulla are continuous throughout the organ.
- The cortex is dark outer zone, contains developing (small) T-cells and many macrophages. It is the site of T- lymphocytes prefiltration, differentiation and maturation. The maturing T-cells in the cortex are protected from blood born antigens by blood –thymic barrier.
- Most of the developing T-cells die in the thymus (90%) and are phagocytosed by macrophages.



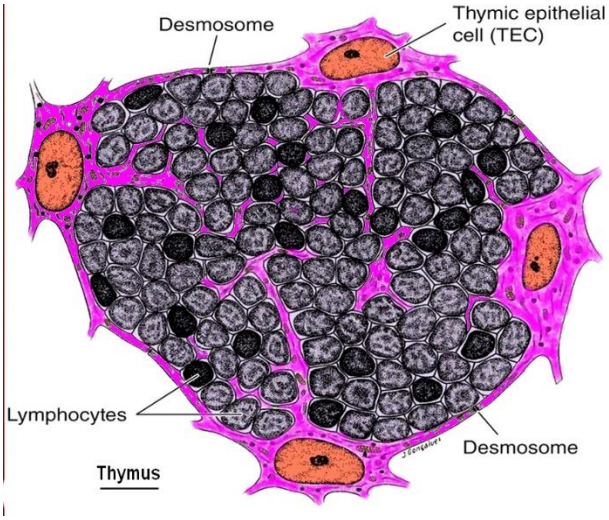
- The medulla is a central light zone containing few lymphocytes and thymic corpuscles.

- The mature programmed T- cells leave the medulla through post capillary venules near the corticomedullary junction. They are carried by the blood to the T – dependent regions of secondary lymphoid organs.



Blood thymic barrier..

- In the thymic cortex continuous capillaries ensheased by a sheet of a thymic epithelial cells form a blood-thymic barrier, that limits the entrance of progenitor cells and macromolecules, providing a protected environment for developing programmed lymphocytes.
- The blood-thymic barrier is formed from the capillary endothelium, its basal lamina, a thin perivascular sheath of connective tissue, the epithelial reticular cells or their cytoplasmic processes and its basal lamina.



Function of the thymus..

- Production of T- lymphocytes is the primary function of the thymus.
- Epithelial reticular cells secrete hormone-like substances, the thymosin, thymopoietin, thymulin and thymotaxin. These hormones are essential for normal development of other lymphatic organs (tonsils, spleen and lymph node) and stimulate differentiation of T- lymphocytes.

Secondary lymphatic organs

- The secondary (peripheral) lymphatic organs include mucosal associated lymphatic tissue (MALT), lymph nodes, spleen and hemal nodes.
- There are two organizations of the lymphatic tissue of the secondary lymphatic tissue: - *diffuse* and *nodular regions* that are supported by reticular connective tissue.
- The *diffuse lymphatic tissue* contains randomly arranged concentrations of lymphocytes, mainly T-cells and other blood leukocytes-derived cells. Clonal expansion of T-cells occurs in this tissue.
- *Lymphatic nodules (follicles)* are oval in shape contain concentration of lymphocytes, mainly B-cells with many macrophages but few other cell types.
- The *stroma* contains follicular dendritic cells (antigen-presenting cells).
- *Germinal center* of each nodule is the central region that appears light because it contains enlarged B-cells undergo clonal expansion. The germinal center appeared in *secondary nodules* and not presented in *primary nodules*.

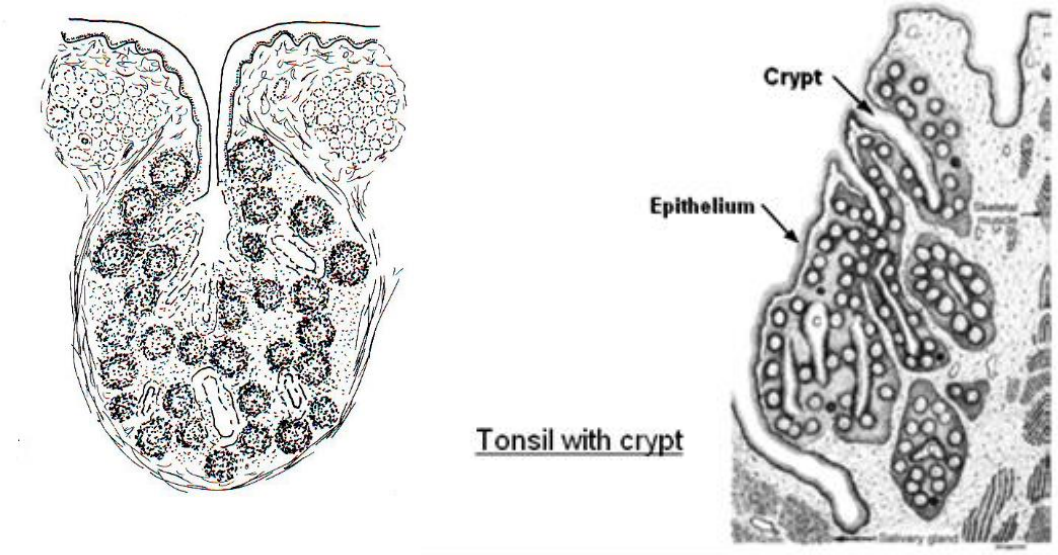
Mucosal associated lymphatic tissue (MALT) :-

- The lymphatic tissue is commonly presented in loose connective tissue in the lamina propria of mucous membranes. These collections are named: -
- *Tonsils*, in the pharyngeal region.
- *Peyer's patches* in the small intestine, primarily the ileum.
- *Gut-associated* lymphatic tissue (GALT).

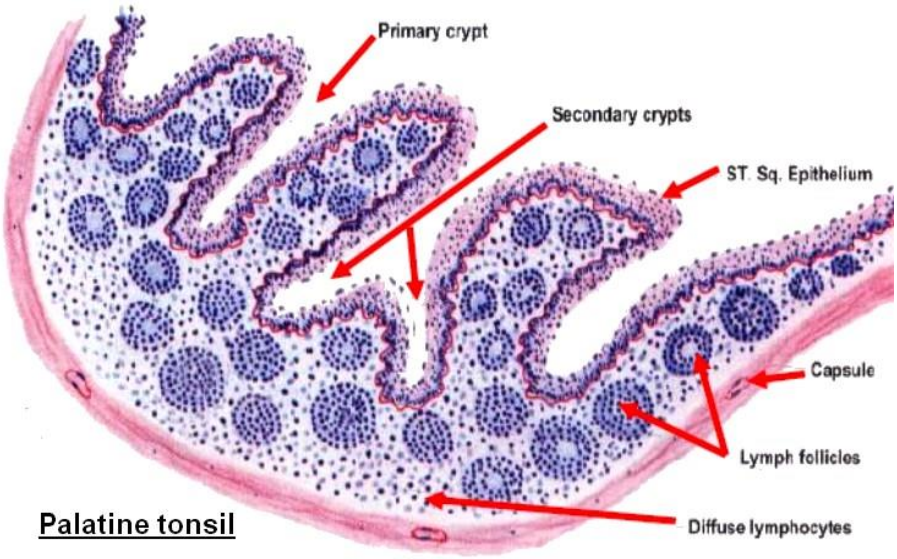
- *Bronchus associated* lymphatic tissue (BALT).
- *Urogenital-associated* lymphatic tissue (U-GALT).

Tonsils ..

- Tonsils are permanent aggregation of lymph nodules in the lamina propria, surrounded by dense fibrous connective tissue capsules. They are present at the entrance of the digestive and respiratory tract.
- The surface epithelium covering the lymph nodules (tonsillar epithelium) increases its surface area either by invagination forming crypts (tonsil with crypts) or irregular folds outward forming sinus (tonsil without crypts) seromucoid glands are associated with the lymph nodules. The duct of which opens in the crypt or on the surface epithelium.

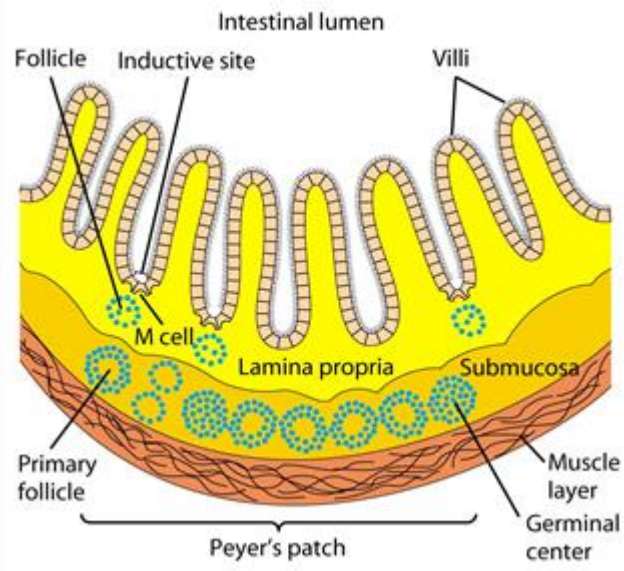


Tonsil with crypt



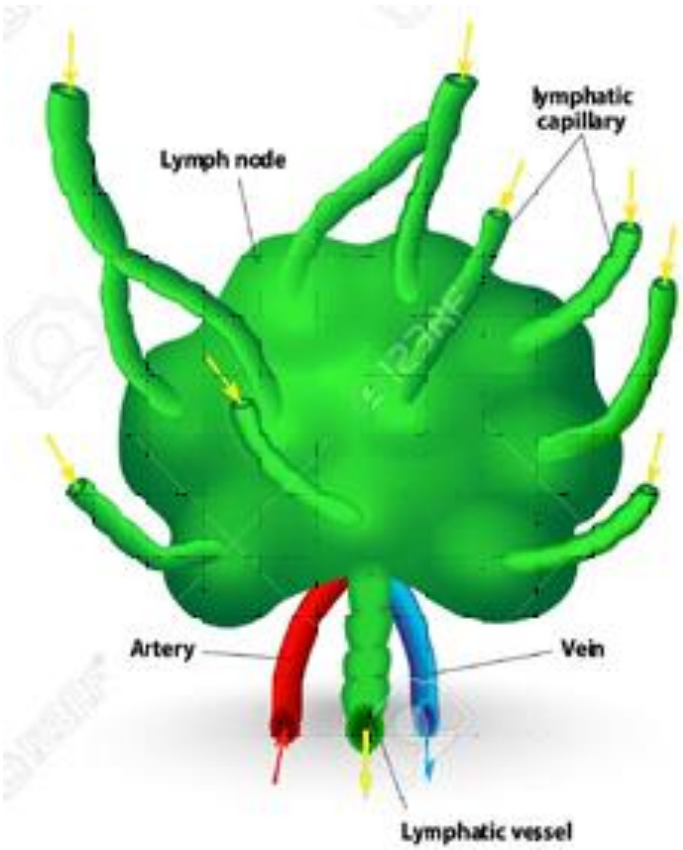
Peyer's patches..

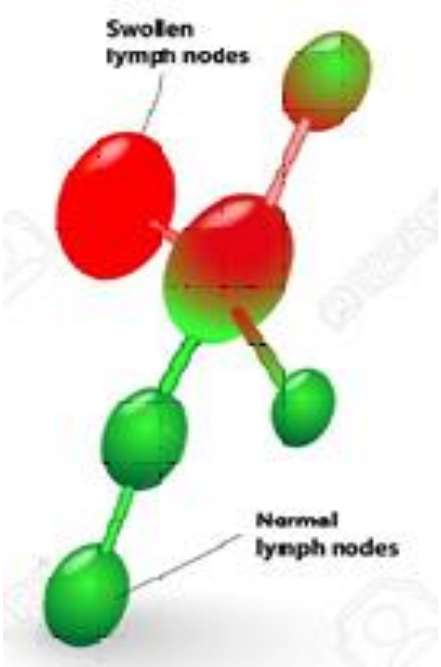
- They are permanent aggregates of lymph nodules in the lamina propria (may extend to submucosa) in the ileum and are surrounded by diffuse lymphatic tissue. They are considered as intestinal tonsils.
- *M-cells* are specialized epithelial cells in the ileum lie over clusters of lymphocytes.
- *In sheep,* and probably in other ruminants, lied Peyer's patches may be the functional equivalent of the clonal bursa in birds for formation of B-cells.

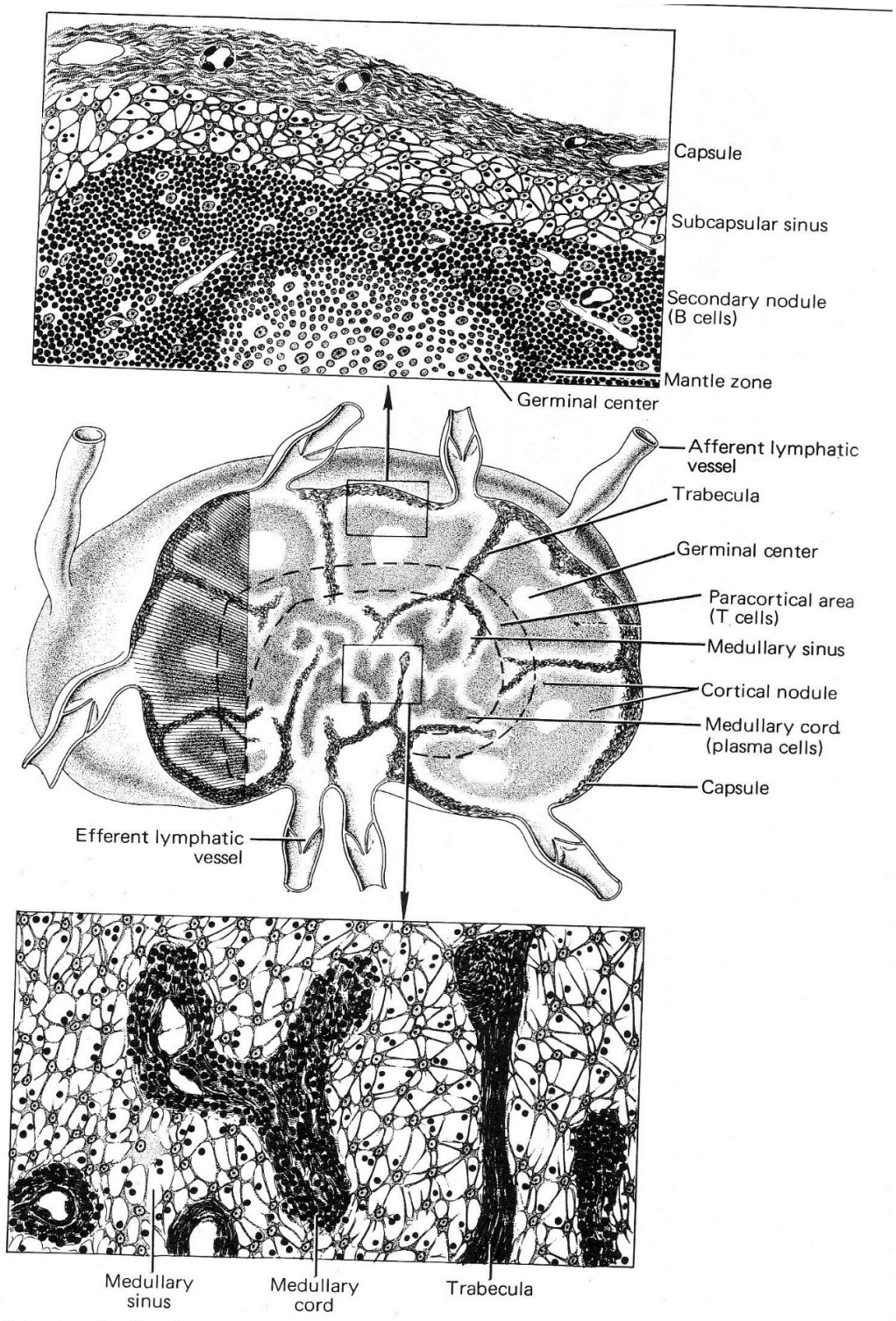


LYMPH NODES

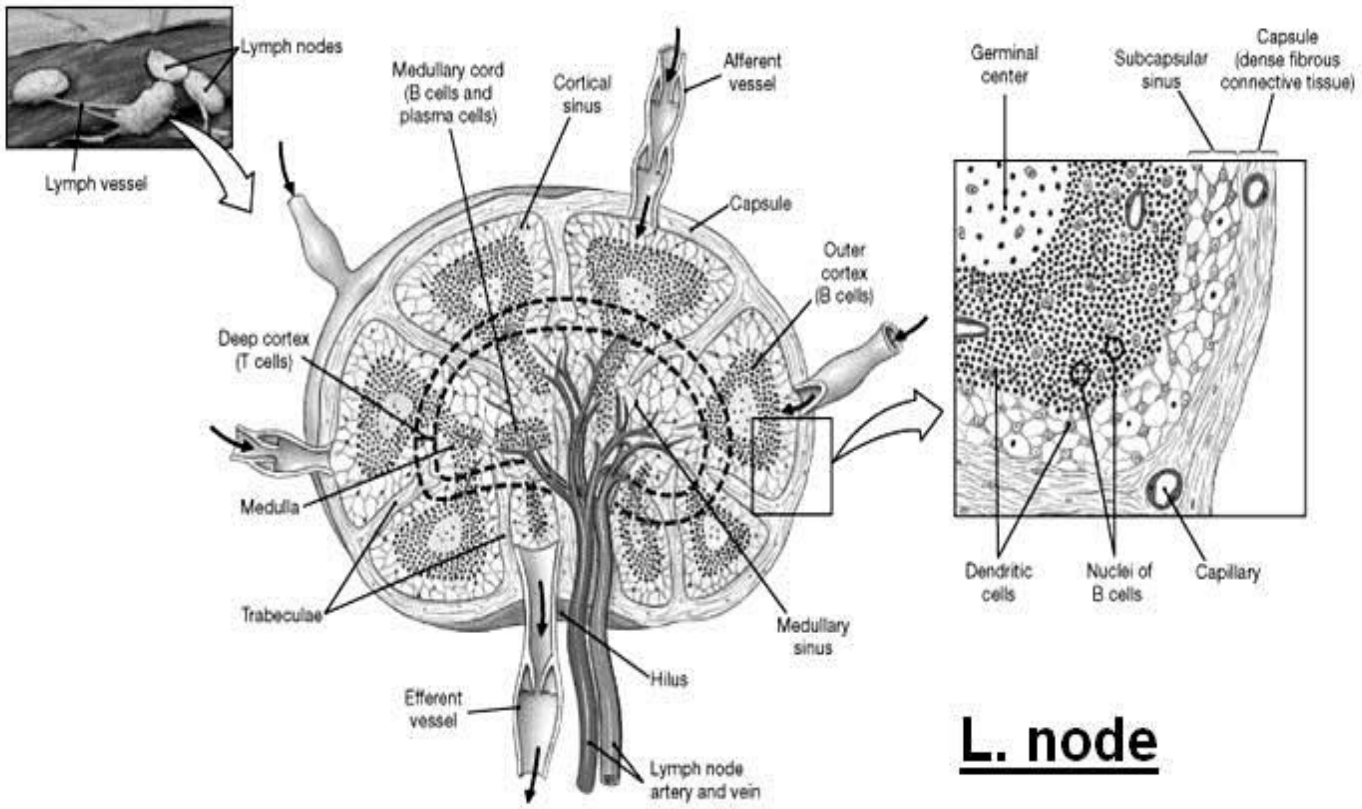
- The lymph nodes are numerous encapsulated lymphoid organs. They are distributed along the lymph vessels all over the body. Most birds do not have lymph nodes.
- The lymph node is composed of stroma, cortex, medulla, lymph vessels and sinuses.







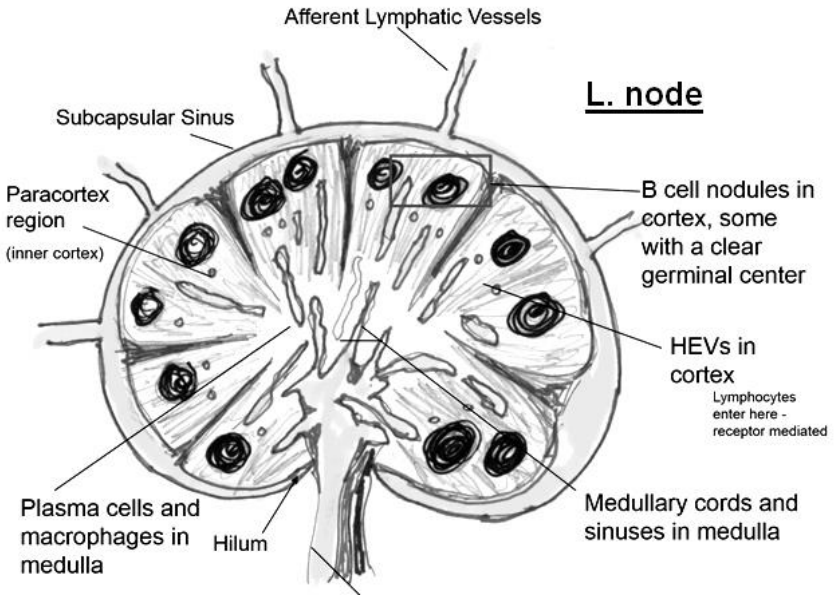
B. Histologic structure of a lymph node. Th


Lymph nodes
Lymph vessel
Medullary cord (B cells and plasma cells)
Cortical sinus
Afferent vessel
Capsule
Outer cortex (B cells)
Deep cortex (T cells)
Medulla
Trabeculae
Medullary sinus
Hilus
Efferent vessel
Lymph node artery and vein
Germinal center
Subcapsular sinus
Capsule (dense fibrous connective tissue)
Dendritic cells
Nuclei of B cells
Capillary

L. node

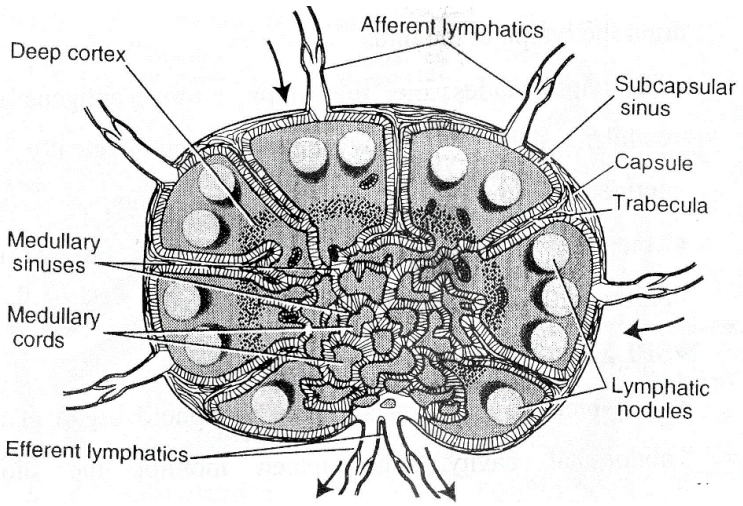
Stroma :-

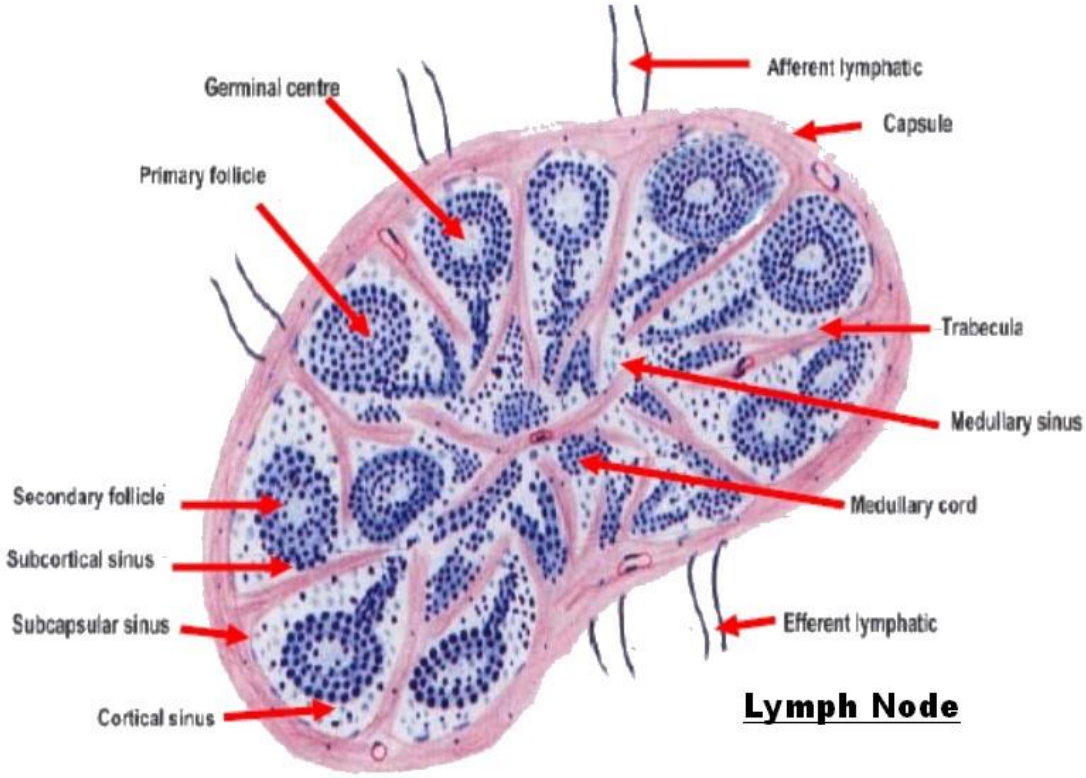
- A dense fibrous connective tissue capsule often contains smooth muscle fibers surrounding the lymph node. Trabeculae extend from the capsule into the parenchyma for supporting and carrying blood vessels and nerves.
- Reticular tissue in the parenchyma contains many macrophages and dendritic reticular cells that have long processes.


Afferent Lymphatic Vessels
L. node
Subcapsular Sinus
Paracortex region
(inner cortex)
B cell nodules in cortex, some with a clear germinal center
HEVs in cortex
Lymphocytes enter here - receptor mediated
Plasma cells and macrophages in medulla
Hilum
Medullary cords and sinuses in medulla

Cortex ..

- The cortex of lymph node contains lymph nodules, diffuse lymphatic tissue and lymph sinuses.
- Between the nodules and the medulla, there is a layer called deep cortex or inner cortex or paracortex that contains diffuse lymphatic tissue and HEV.

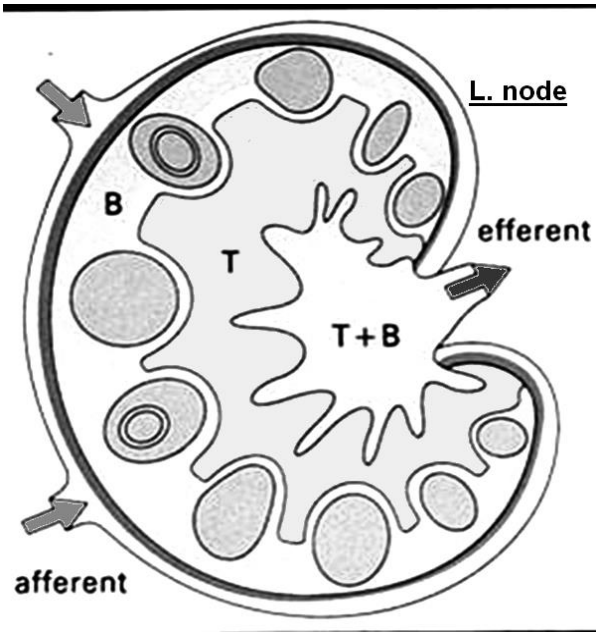




Lymph Node

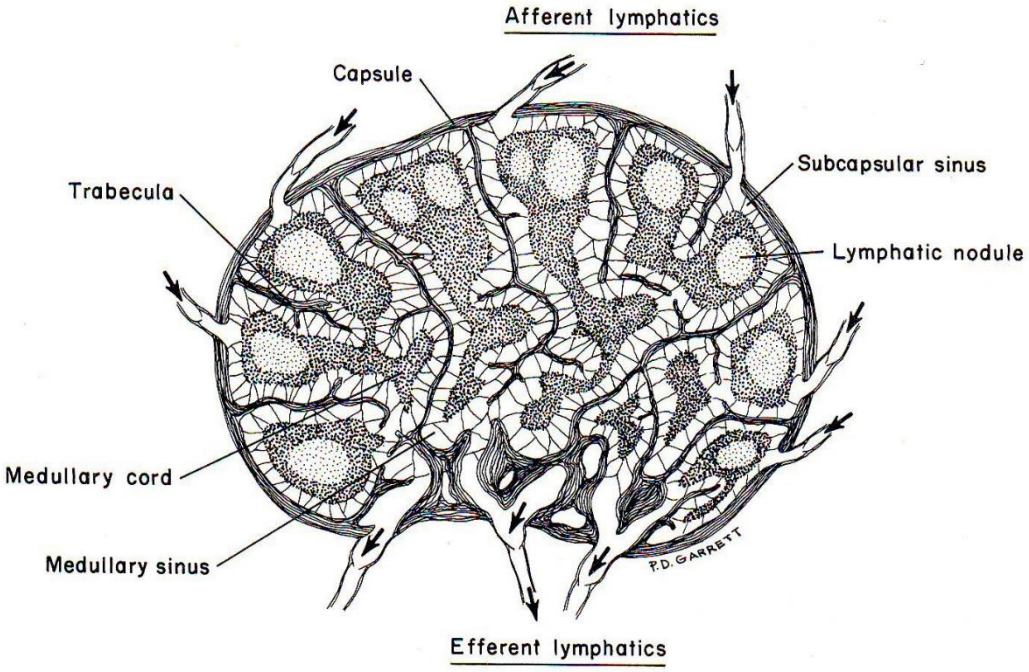
Medulla..

- The medulla of the lymph node consists of anastomosing thick cords of diffuse lymphatic tissue separated by lymph sinuses. It contains many plasma cells.



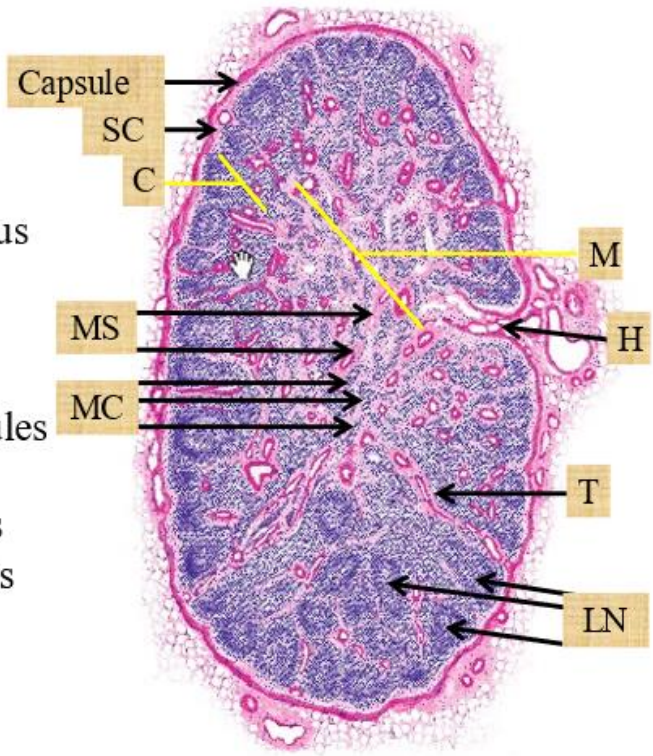
Lymph vessels and sinuses..

- The afferent lymph vessels and sinuses are lined with endothelium. They are channels for the flow of lymph.
- The wide lumen is traversed by processes of macrophages, and antigen-presenting dendritic cells and by reticular fibers.
- The lymph flows from afferent lymph vessels to subcapsular sinus, then trabecular sinuses, to medullary sinuses and finally to efferent lymphatic vessels that drain the lymph at the hilus.
- The lymph nodes filter the lymph, remove antigens and cellular debris. They respond immunologically to antigens and produce lymphocytes and add Igs.
- Macrophages associated with the sinuses remove the particular matter in lymph.



Lymph node

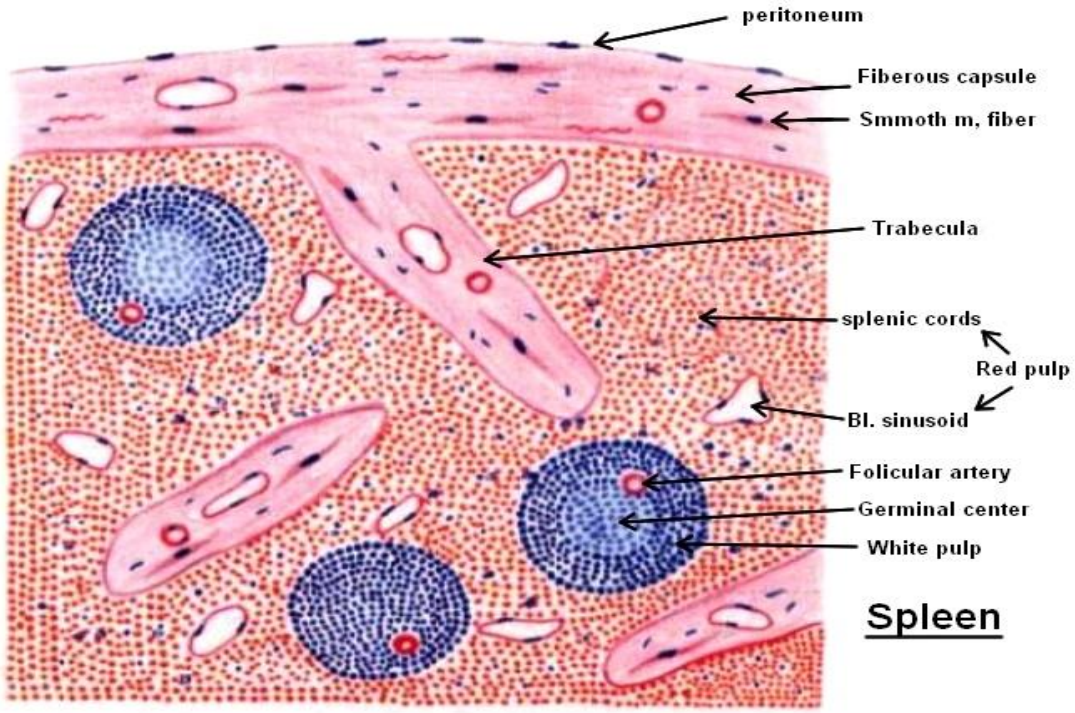
SC --- Subcapsular Sinus
C --- Cortex
M --- Medulla
H --- Hilum
LN --- Lymphatic Nodules
T --- Trabeculae
MS --- Medullary Sinus
MC --- Medullary Cords



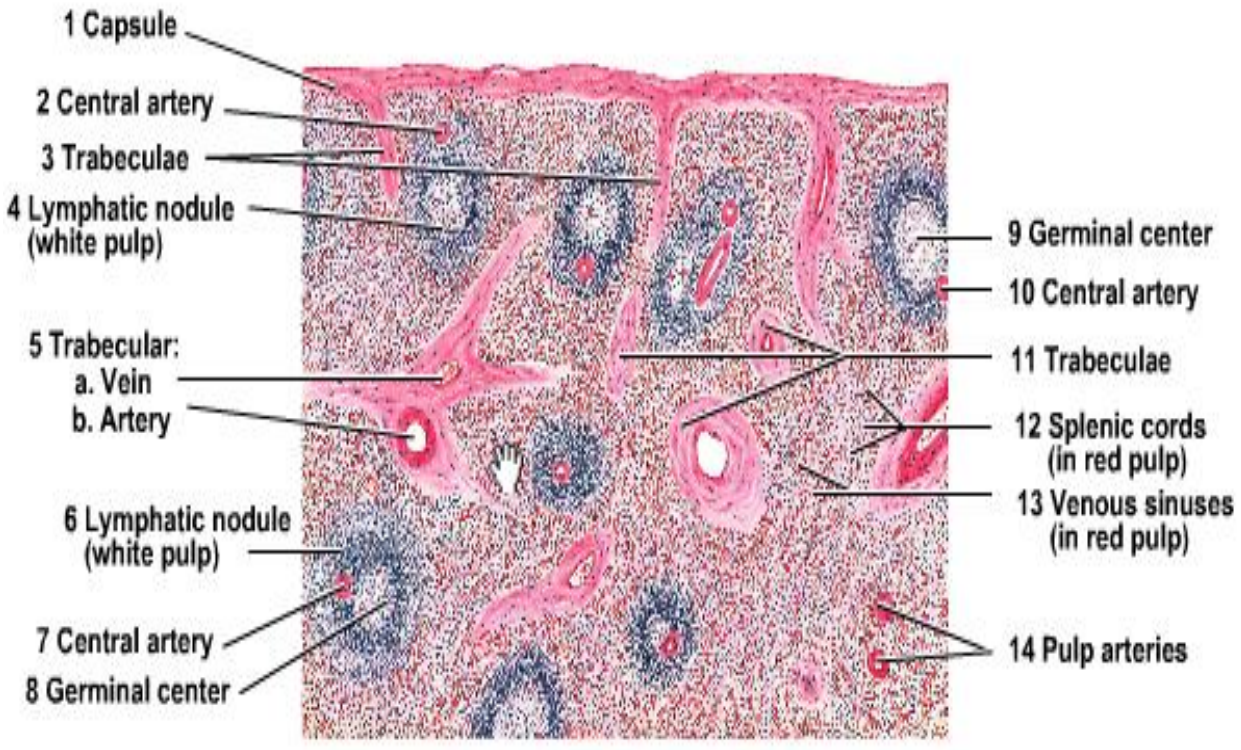
SPLEEN

- The spleen is large encapsulated lymphoid organ in the abdominal cavity. The spleen monitors the blood immunologically.
- The spleen is surrounded by dense connective tissue capsule, from which trabeculae are extended in the substance of the organ. The capsule and trabeculae often contain smooth muscle bundles. The capsule is covered by mesothelium.
- The parenchyma of the spleen is composed of white pulp and red pulp. It has no cortex and medulla.
- The white pulp consists of lymph nodules (splenic nodules) and the diffuse *periarterial lymphatic sheaths* (PALS) around small arteries and arterioles called arteries of the white pulp (central arteries).

- The red pulp consists of blood spaces (pulp spaces), venous sinuses or venules and cell-filled spaces between the sinuses which contain the splenic cords.

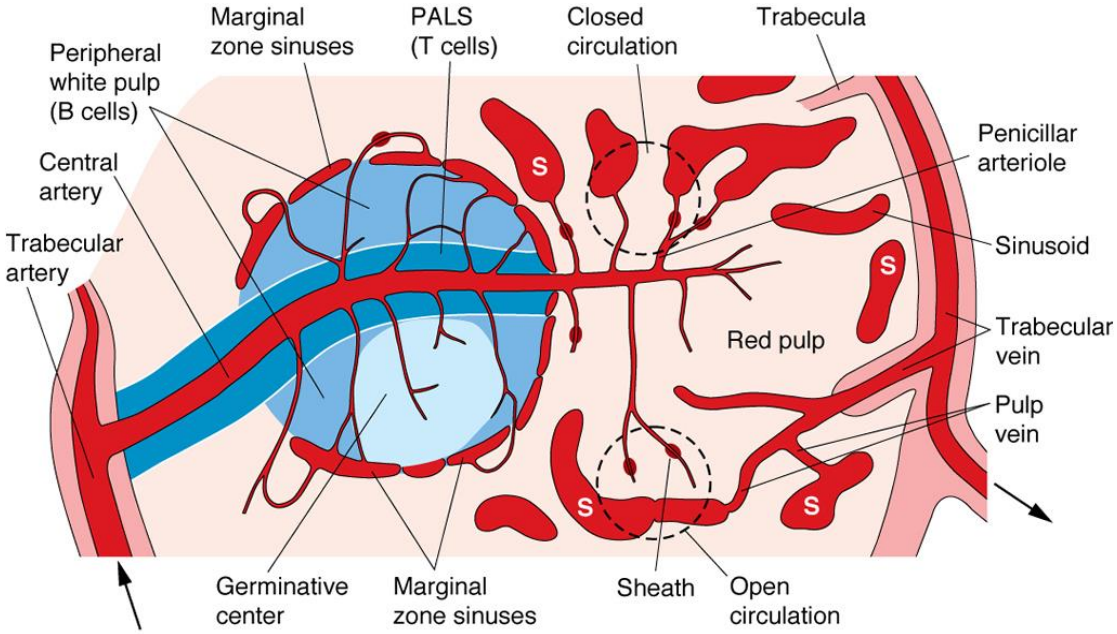


- ***Macrophages*** are numerous in the red pulp.
- The marginal zone between white pulp and red pulp contains lymphocytes, monocytes and other blood cells.
- The splenic artery branches enter the hilus and ramify in the capsule into trabecular arteries which run in the connective tissue trabeculae. Then they leave the trabeculae and enter the splenic pulp and called arteries of the white pulp or the central arteries.
- The central artery loses its adventitia and is surrounded by a sheath of lymphatic tissue called *periarterial sheath* (PALS). The periarterial sheath bulges here and there forming lymph nodules (the splenic nodules)



- Nodular arterioles, PALS arterioles and marginal arterioles which empty into the marginal zone are branches from the central arteries
- Penicilli are brush-like terminations of the central arteries.
- Each penicillar arteriole gives rise to 2-3 sheathed capillaries (ellipsoids). They are surrounded by sheaths of macrophages and reticular cells.
- The capillaries terminate beyond the sheathed region in the red pulp.
- According to the open circulation, capillaries open into splenic cords.
- According to the closed circulation the capillaries open into splenic sinusoids or venules.
- Splenic sinuses are lined by long fusiform endothelial cells separated by narrow intercellular clefts. The wall of the sinus is supported by a discontinuous basal lamina.
- Splenic sinuses or venules join and empty into veins of the red pulp which drain into trabecular veins.

- The spleen is either of sinusal or nonsinusal type.



Blood circulation in the spleen

Function of the spleen :-

- The splenic white pulp is the main source of humoral antibodies.
- The spleen removes the defective and the aged blood cells.
- The spleen acts as blood cell storage specially erythrocytes and platelets.
- The spleen is an important hemopoietic organ during fetal life.

HEMAL NODES

- The hemal nodes are found primarily in the ruminants, specially in sheep.
- The hemal nodes resemble lymph nodes, but they have blood in their sinuses. The sinuses are very wide. There is no typical medulla.
- The hemal node is surrounded by fibrous connective tissue capsule from which trabeculae support the node. The hemal sinuses are :- subcapsular, trabecular and pare

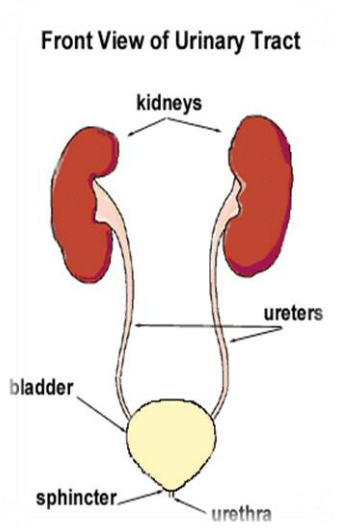
URINARY SYSTEM

Prof. Dr. / Saad Emara

Urinary System

- The urinary system consists of two kidneys and urinary tracts (two ureters, the urinary bladder, and the urethra).

-Urinary organs filter blood, saving useful metabolites and remove metabolic waste products, excreting them outside of the body (as exocrine function).



- The kidney plays a role in regulation of blood pressure through secretion of proteolytic enzymes (renin) act as (endocrine function). Also, the kidney plays a role in regulation of erythropoiesis through secretion of renal erythropoietic factor (erythropoietin) act as endocrine function.

1-THE Kidney

- The kidney is a compound tubular gland that performs a vital function as well as urine formation.

- The kidneys are paired organs anatomically they are situated retroperitoneally on the dorsal wall of the abdominal cavity on either side of the vertebral column.

DEVELOPMENT OF THE KIDNEY: -

- The kidney develops from two principal origins at the early embryonic life.

1-The *ureteric bud* divides in dichotomously manner forming the collecting part of the kidney (pelvis, calyces, papillary ducts, straight ducts and collecting tubules).

2-The *metanephrogenic mesenchyme* (metanephric blastema) capped on the ureteric bud and divided with its division then differentiate to form nephrons.

Histological Structure of the kidney:

1- Renal stroma:

A- Renal capsule**:**

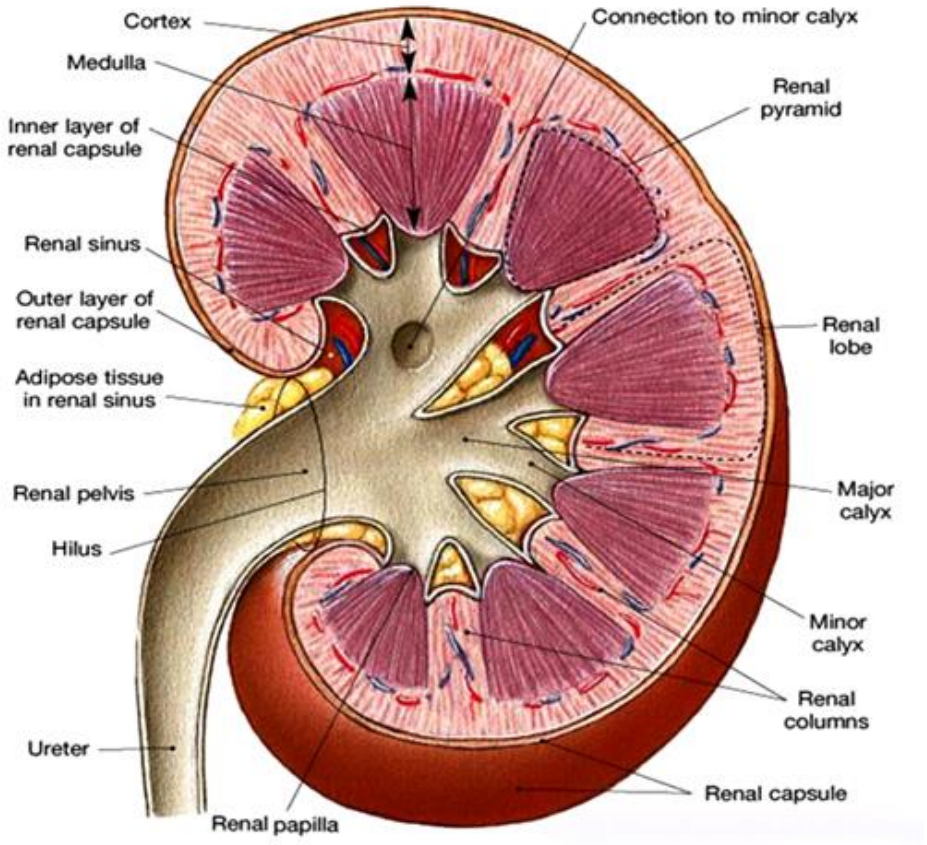
The kidney is closely invested by a thin but strong capsule of dense fibrous connective tissue. The capsule contains smooth muscle fibers in some species.

The fibrous capsule is covered by perirenal fat (*capsula adiposa*) except at its contact with peritoneum where it is covered by mesothelium.

B- Renal interstitial:

The interstitial connective tissue is scant and mainly is found around the blood and lymph vessels and nerves.

It is believed that some of the interstitial cells secrete prostaglandin hormone that regulates blood pressure.

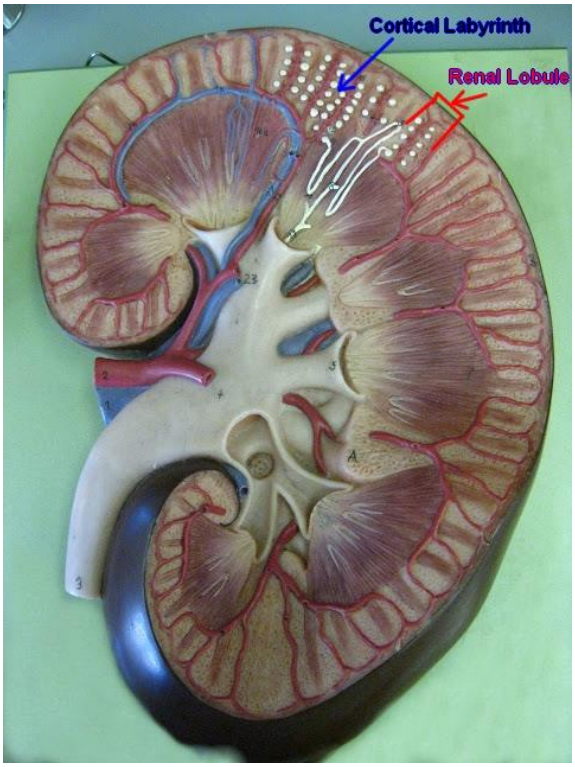


Cross section in Kidney

2- <u>Renal parenchyma</u>

The functional unit of the kidney is the **uriniferous tubule**. Each uriniferous tubule consists of two principal portions. The first portion, the **nephron** is concerned with the formation of the urine. The second portion, **the collecting duct system**, carries out a final concentration of urine to form hypertonic urine and conveys it to the renal pelvis. Each ***nephron*** consists of glomerular capsule (of *Bowman*), proximal tubule, nephron loop (of *Henle*) and distal tubule. Each of proximal and distal

tubule consists of convoluted and straight portion. A thin segment connects the straight portion of proximal tubule to the portion of distal tubule. These three segments form a loop called the nephron loop (of *Henle*) extending from the cortex for a variable distance into medulla.



The Collecting duct system is the portion of the uriniferous tubules that concentrate, collect, and convey urine. It consists of arched collecting tubules, straight collecting tubules, and papillary ducts (of *Bellini*).

- ❖ Two distinct regions can be distinguished in the kidney with naked eye: A darker, reddish-brown cortex and a lighter medulla.

A- Renal cortex

It is peripherally located, dark brownish red granular zone

Two distinct regions are visible in the renal cortex, the cortical labyrinth or "*cortex proper* "and the medullary rays.

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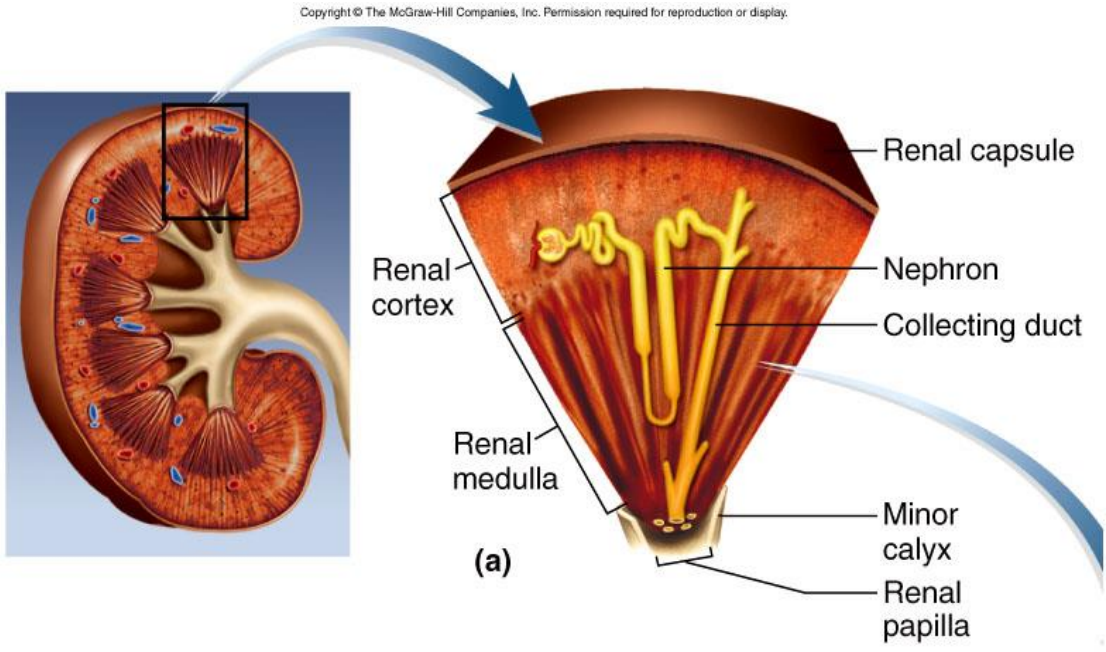


Structure of nephron

- **Renal cortical labyrinth:**

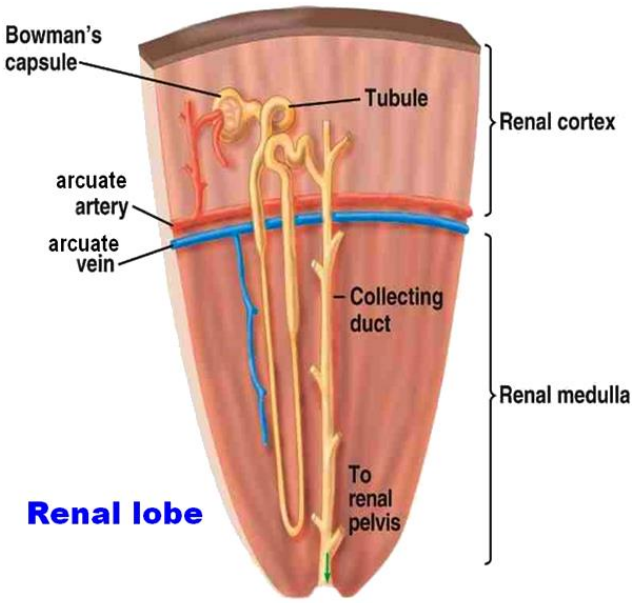
-It is the granular portion of the renal cortex. It consists of renal corpuscles and convoluted portions of the nephron and arched collecting tubules.

- **Medullary rays:**

Are composed of the straight collecting tubules together with the descending and ascending limbs of nephron loop. Each medullary ray and its immediately associated nephrons that empty into the branched colleting ducts of this ray is called "renal lobule*"*

B- . Renal medulla

The **medulla** contains nephron loops and straight collecting tubules, together with the papillary ducts. The medulla is made up of number of conical subdivisions called "*renal pyramids"*. A renal pyramid together with cortical tissue that present at its base called *"renal lobe"*.



Classification of the kidney:

According to the morphological features of the cortex and medulla, the kidney is classified into the following types: -

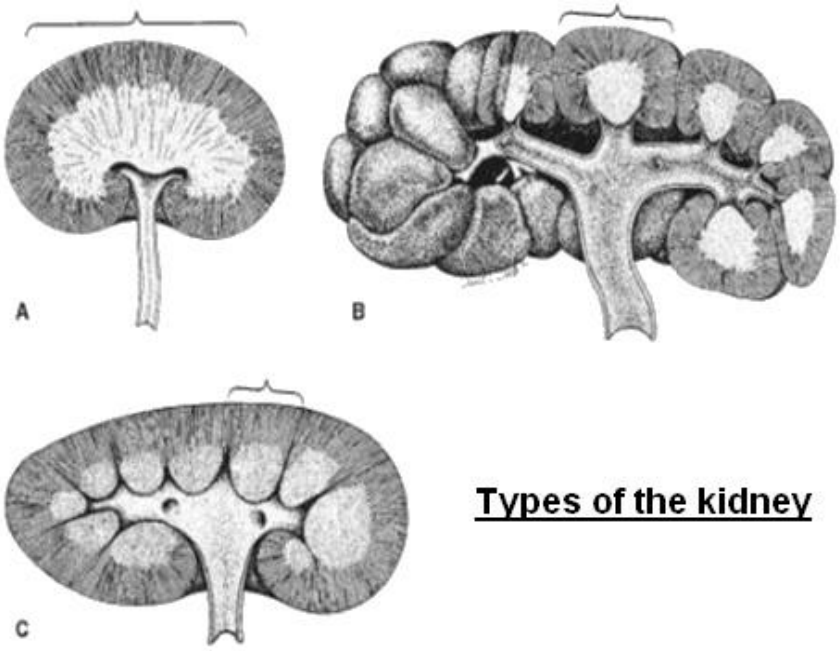
1-**Smooth unipapillated kidney***:* in horse, camel, small ruminants, and carnivores. The cortical substance fuses completely in one mass with smooth outer surface.

The medullary tissue also fuses completely and projects by a common papilla or crest opens in the renal pelvis.

2-**Smooth multipapillated kidney***:* - in swine and human, the cortical substance fuses completely, while the medullary tissue incompletely fused. The medullary pyramids are separated from each other and each of them open into a minor calyx.

3- **Furrowed multipapillated kidney***:* - In large ruminants the cortical tissue as well as medullary tissue is incompletely fused. So, the kidney appears superficially divided by furrows of variable

depth, and the renal pyramids are separated, and each opens into a minor calyx.



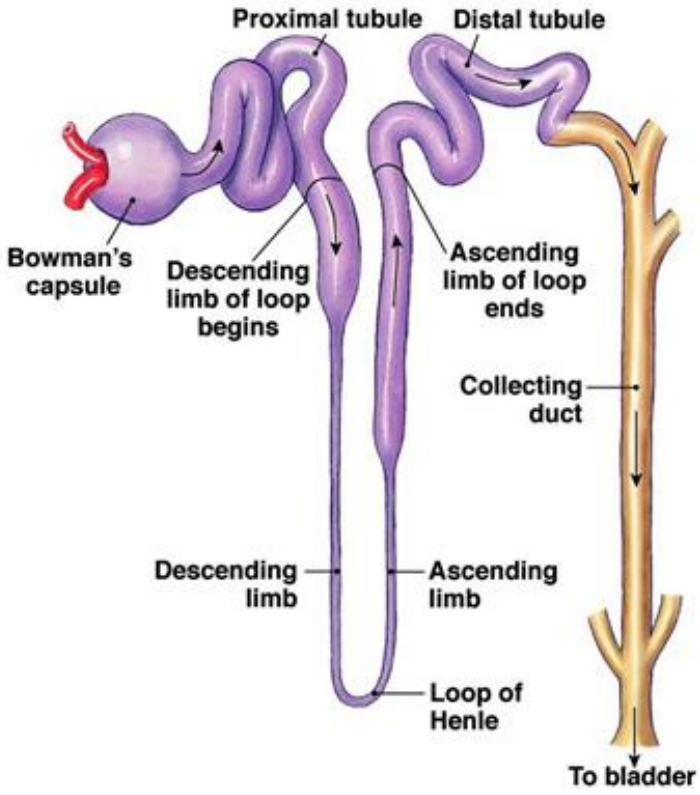
Types of the kidney

A. Unilobar kidney - carnivores, equine and small ruminants
B. Multilobar - large ruminants, smooth surface, clear demarcation
C. Multilobar - pig, cortical portion of the lobes fused

- **Histological structure of the nephron: -**

The nephron is the tubular functional unit in the kidney.

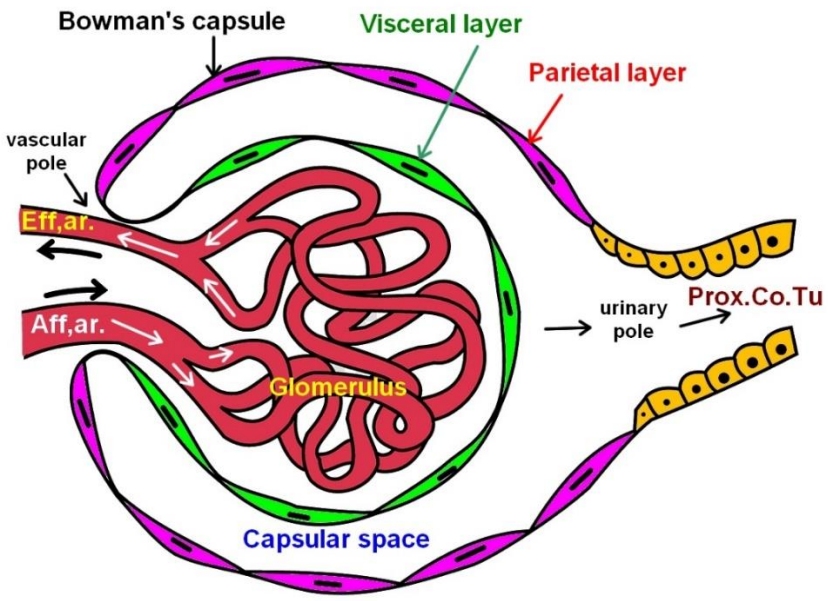
Each nephron is composed of renal corpuscle, proximal convoluted tubule, nephron loop (of *Henle*) and distal convoluted tubule.

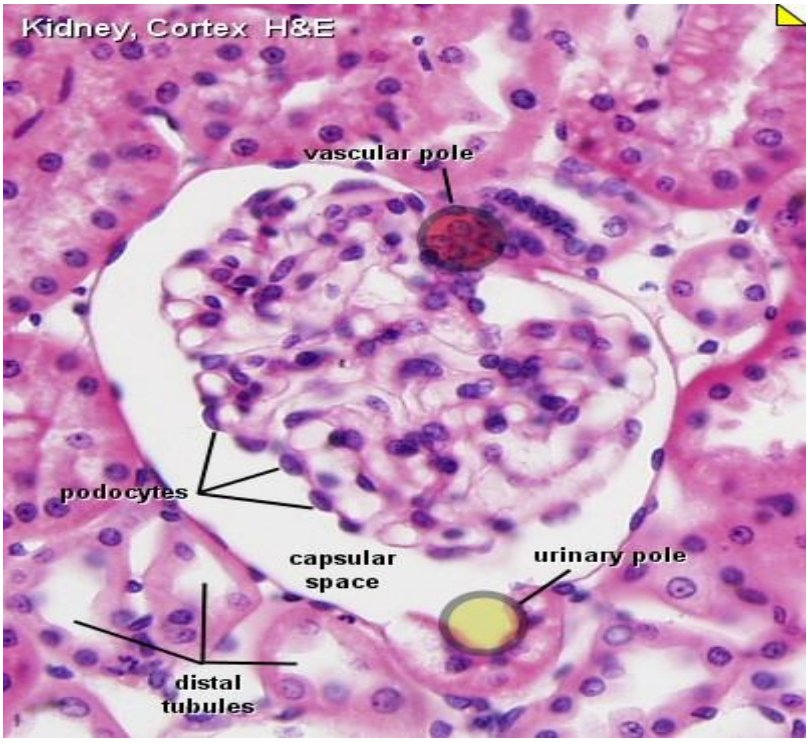


1- Renal corpuscle: -

- The renal corpuscle consists of a glomerular capsule around the tuft of glomerular capillaries. The *glomerular capsule* (of *Bowman*) is a cup- shaped double walled epithelial capsule. The inner layer of the capsule is closely applied to the capillaries and is called the **visceral layer,** and the external layer is called the **parietal layer**. The space between the layers is called *capsular space.*

The parietal layer is composed of simple squamous epithelium, but the visceral layer is composed of modified epithelium called *podocytes*. Each renal corpuscle has two poles, *vascular pole,* where the afferent arterioles are present and *urinary pole* at the beginning of the proximal convoluted tubules.





Schematic drawing of renal corpuscle: The upper part shows the vascular pole, with afferent and efferent arterioles and the macula densa. Juxta glomerular cells in the wall of afferent arteriole. podocytes cover glomerular capillaries, the lower part showing the urinary pole and proximal convoluted tubule.

Podocytes: -

- They are closely applied to the capillaries. The nucleus presents in the cell body. The cell has several primary processes that give rise to very numerous secondary processes that are also called foot processes or *pedicels*.

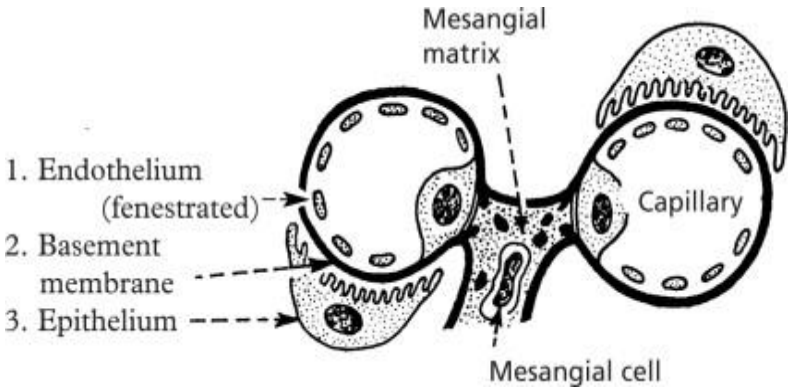
- The pedicels interdigitate with corresponding elements of neighboring podocytes forming a system of intercellular clefts called *filtration slits*. This structure provides an area of pores for filtration. The primary processes as well as the cell bodies of podocytes do not touch the glomerular capillaries.

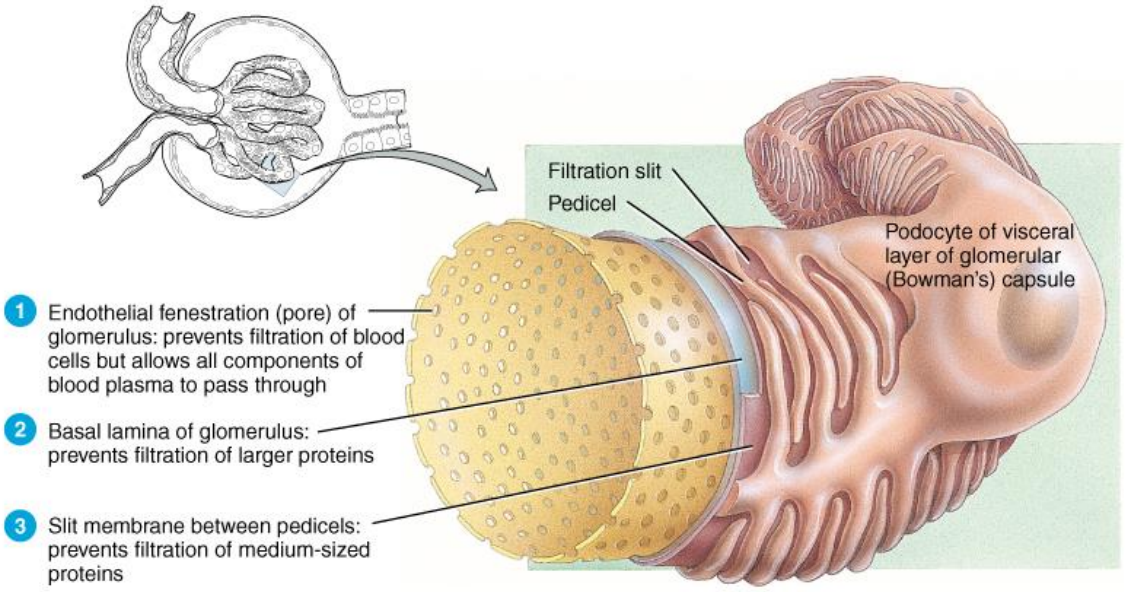
The filtration slits between the interdigitating pedicels, the basal lamina and the endothelium of the glomerular capillaries, together form the filtration barrier or *blood –urine barrier*. Podocytes provide support of hydrostatic pressure during filtration.

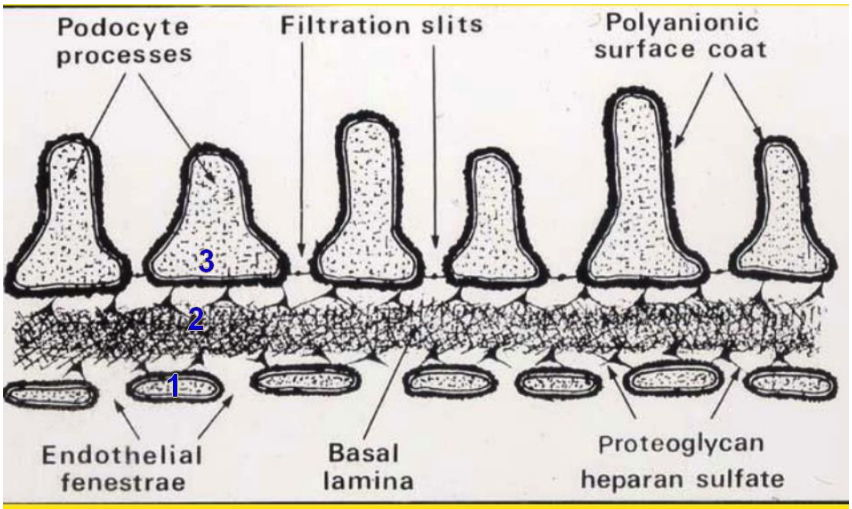
Intra glomerular mesangial cells:

-They are specialized pericytes, which provide structural support phagocytic and contractile function. Their plasma membrane possesses receptors for *Angiotensin II* and *Atrial Natriuric Peptide.*

-Each renal corpuscle has two opposite poles; a vascular pole (site of entrance and exit of afferent and efferent glomerular arterioles) and a urinary pole (origin of proximal tubule).




Filtration slit
Pedicel
Podocyte of visceral layer of glomerular (Bowman's) capsule
1 Endothelial fenestration (pore) of glomerulus: prevents filtration of blood cells but allows all components of blood plasma to pass through
2 Basal lamina of glomerulus: prevents filtration of larger proteins
3 Slit membrane between pedicels: prevents filtration of medium-sized proteins



Glomerular Filtration Barrier

2-Proximal tubule

The renal tubule makes up the bulk of the renal cortex. Each is composed of convoluted portion (*pars convoluta*) situated in the cortical labyrinth and straight portion (*pars recta*) located in the medullary rays.

The proximal tubules connect between the renal corpuscle and the thin segment of the nephron loop.

With L.M. The proximal tubule has narrow lumen and is lined by high cuboidal cells with ill-defined cell boundaries and more acidophilic cytoplasm. The nucleus is spherical and situated near the base of the cell. The free surface of the cell carries brush borders while the cytoplasm showed basal striation. Toward the straight part of the tubule, the cells become lower with longer brush border and less basal striation.

3- Intermediate tubule (thin segment): -

The intermediate tubule is the thin segment that connects between the descending straight part of the proximal tubule and the ascending straight part of the distal tubule.

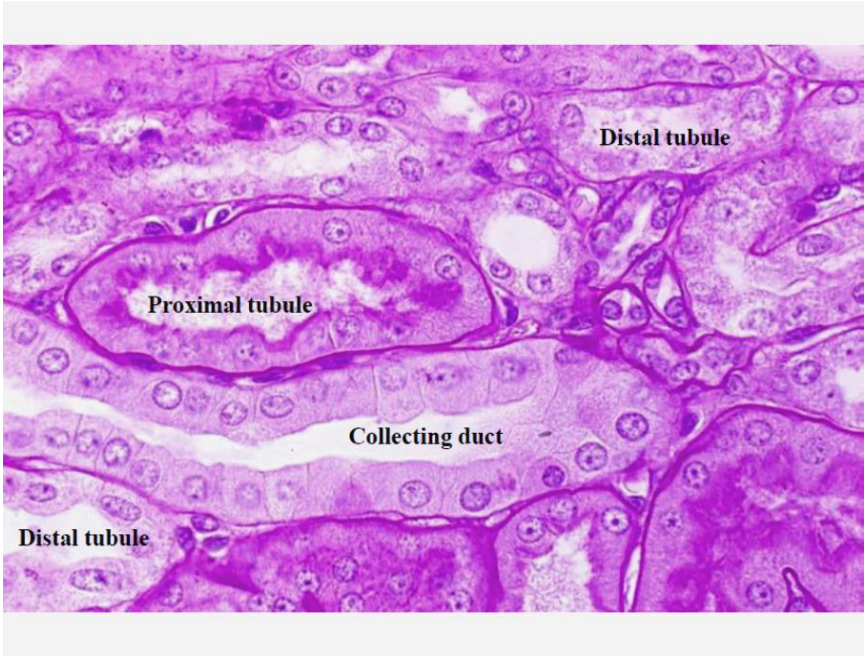
With *L.M*, it is lined with flat squamous cells with oval nuclei that bulge slightly into the lumen.

4-Distal tubule

The distal tubule is the segment of the nephron connecting between thin segment of nephron loop and the arched collecting tubule. Each is composed of convoluted part and straight part.

With *L.M* the distal tubule has wider lumen than that of proximal one.

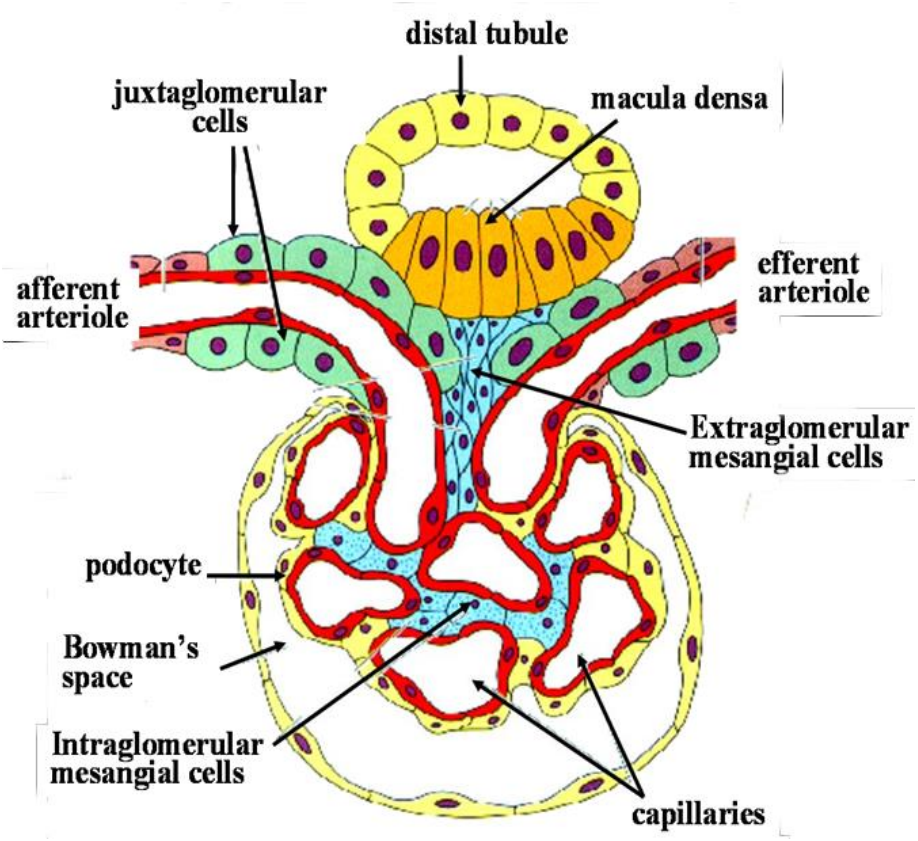
It is lined by cuboidal cells that lake brush border. Their cytoplasm is pale, less acidophilic and the nuclei are spherical and situated towards the apical surface of the cells. The basal cytoplasm of the cells shows basal striation.



Juxtaglomerular apparatus: -

The juxtaglomerular apparatus presented at the vascular pole of the renal corpuscle. It consists of three cell types: *juxtaglomerular cells* of afferent arteriole, *macula densa* of distal tubule and *extraglomerular mesangial cells*.

At the point where the afferent arteriole enters the renal corpuscle, the smooth muscle cells of tunica media become modified granular secretory cells and called juxtaglomerular cells "*J.G. cells*".



1- **The juxtaglomerular cells** are in close contact with endothelium of the arteriole and are near to blood in the lumen.

They secrete the proteolytic enzyme renin that converts the "*Angiotensinogen"* plasma protein in blood to "*Angiotensin I"* which is converted by convertase enzyme secreted by capillaries of the lung to "*Angiotensin II"*.

2-Macula densa.

It is formed where the ascending straight portion of distal tubule is in close contact with afferent arteriole of its nephron. The cells of macula densa are narrow, taller and appear denser and their nuclei are closer together. Their function may monitor the osmolarity and volume of the

fluid in the distal tubule and transmitte this information to J.G. cells via gap junctions existing between the two cells.

3-Extraglomerular mesangial cells.

They are called polkissen cells and lacis cells. They are lightly stained polyhedral cells lie in close contact with J.G. cells and macula densa cells between the afferent and efferent arterioles adjacent to the glomerulus. They have unknown functions.

Renal medulla: -

The renal medulla is divided into outer and inner zones.

The renal medulla is composed of the straight portions of both proximal and distal tubules (thick segment of the nephron loop), the intermediate tubule (thin segment of the nephron loop), straight collecting tubules and numerous blood capillaries.

Collecting duct system: -

The connection of the nephron with the collecting tubules is located in the cortex of the kidney along medullary rays. The *arched collecting tubules* present in the cortical labyrinth and connect between the distal tubules and the straight collecting tubules. The *straight collecting tubules* pass inward the medullary rays then join at the acute angles in the inner zone of the medulla with other similar tubules that open in the large straight tubules called papillary *ducts*. The small collecting tubules are lined with cuboidal cells with very clearly outlined. They have spherical darkly stained nuclei and clear pale cytoplasm.

The lining cells of collecting tubules gradually increase in the height from low cuboidal in the outer part of the medulla to cuboidal and finally to low columnar in the papillary ducts.

Renal pelvis

The renal pelvis is the excretory passage that conveys the urine from the parenchyma of the kidney to the ureter

With *L.M* the wall of the renal pelvis is formed inward outward from transitional epithelium, loose connective tissue lamina propria rich in blood vessels, muscular coat and loose connective tissue tunica adventitia.

The muscular coat has three layers, inner and outer longitudinal and middle circular layer of smooth muscle fibers separated by loose connective tissue.

In equine, the propria contains simple branched tubule-alveolar seromucoid gland.

BLOOD SUPPLY OF KIDNEY: -

Each kidney receives blood from its ***renal artery*** which enters through the hilus and divides into several ***interlobar arteries*** locates between the renal pyramids.

At the level of the corticomedullary junction, the interlobar arteries form the ***arcuate arteries*.**

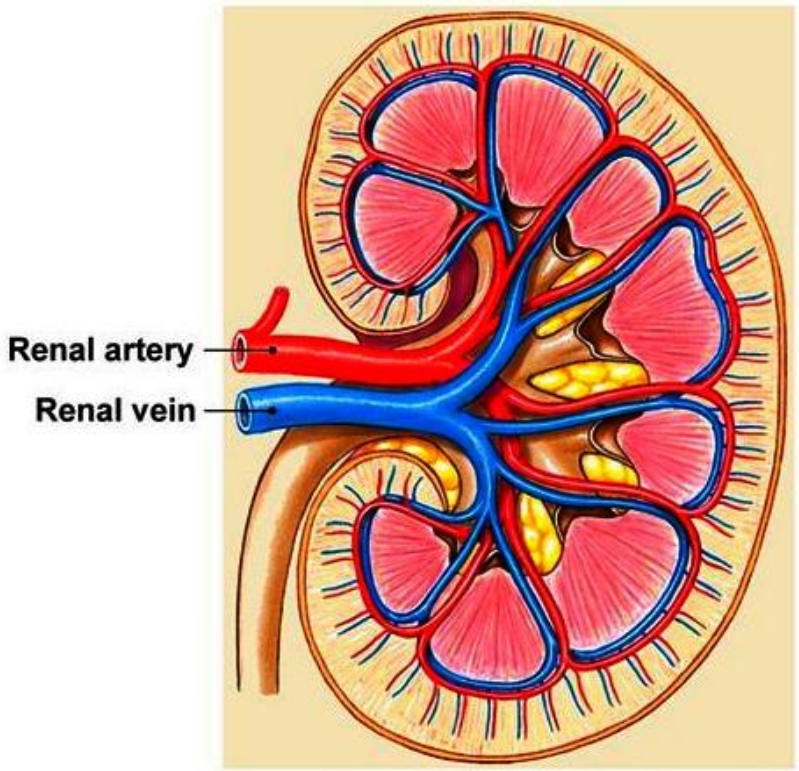
From the arcuate arteries, ***interlobular arteries*** branch off at right angles in the cortex perpendicular to the renal capsule. The interlobular arteries form the boundaries of the renal lobules. They give rise to

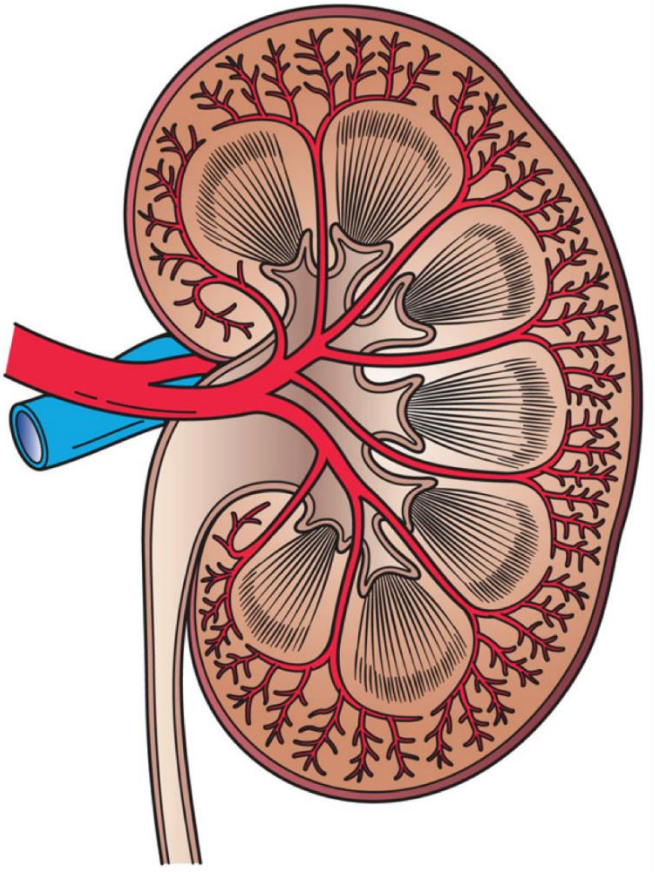
numerous *afferent arterioles* supplying the glomerular capillaries with blood.

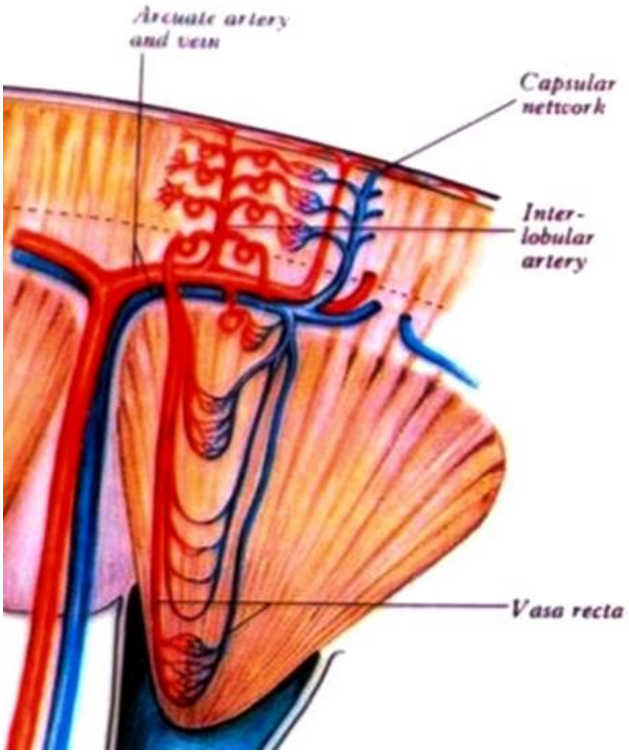
From these capillaries blood passes into the *efferent arterioles* which at once branch again to form a peritubular capillary network around the proximal and distal convoluted tubules.

The efferent arterioles give rise to *false straight arteries* extending into the medulla. Also, *true straight arteries* originate from the arcuate arteries to the medulla.

The interlobular arteries continue to the surface and terminate as capsular plexus. Veins follow the same course as arteries.







Urinary passages

Urinary passages are the pathways transporting the urine from kidneys to the outside of the animal body. They include calyces; minor and major, the renal pelvis, the ureters, the urinary bladder and the urethra.

They have a general histological structure (4- layers) as follows:

1-Tunica mucosa: transitional epithelium

2-Properia-submucosa: loose fibro elastic connective tissue.

3-Tunica muscular is: smooth muscle fibers arranged in two inner, outer longitudinal and middle circular muscle layers.

4-Tunica serosa or adventitia: loose connective tissue covered by mesothelium

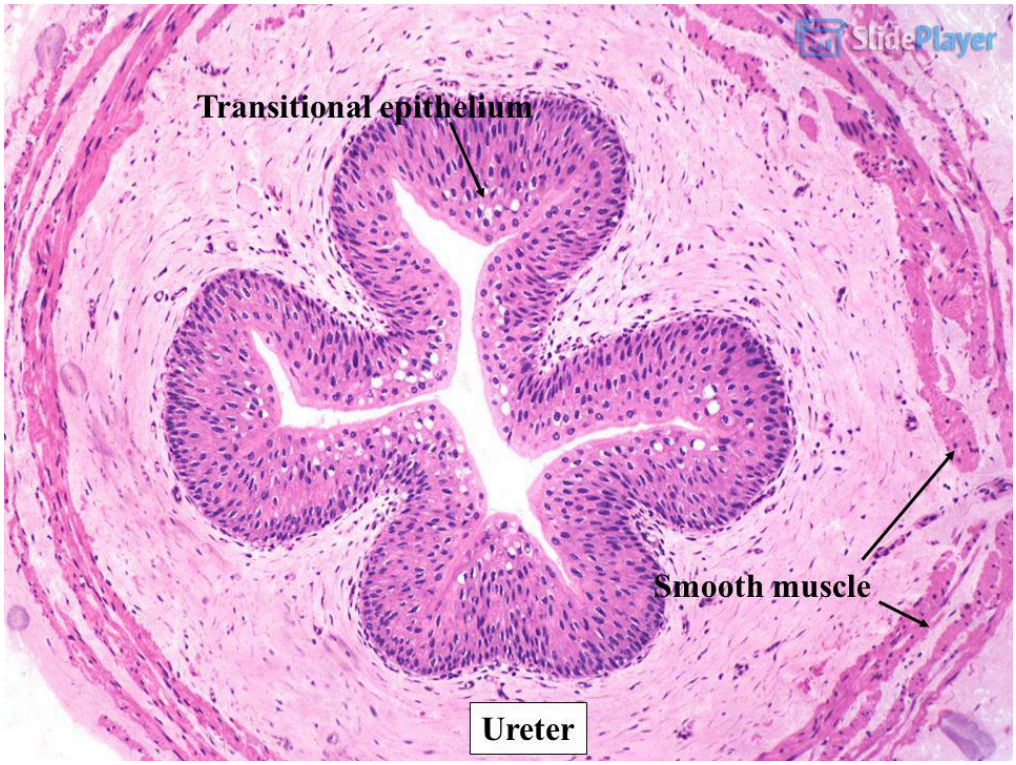
URETER

The ureter conducts the urine formed in the kidney into the urinary bladder.

The mucosa of the ureter consists of *transitional epithelium* (urothelium) rests on a fibro-elastic connective tissue propria-submucosa, which in equine contains simple branched tubule-alveolar glands.

The tunica muscularis has three ill-defined layers, inner and outer longitudinal with middle circular layers of smooth muscle fibers separated by loose connective tissue.

The outer coat of the ureter may be either an adventitia or a serosa according to the location of the ureter.



THE URINARY BLADDER

The urinary bladder stores the urine and then conducts it to the exterior.

-The lining epithelium of the urinary bladder is transitional epithelium (urothelium) which varies in thickness depending on the degree of the distention. which is thick (6-8 layers) in the empty bladder and become thinner (3 layers) in distended bladder

-The propria-submucosa is loose fibro-elastic connective tissue.

-The muscular coat is formed from smooth muscle fibers that run in every direction (without distinct layers) until near the bladder nick, three distinct layers can be identified.

-The outer coat of the bladder is serosa except its retroperitoneal part which is covered by adventitia.

Urethra

The urethra is a tube that carries the urine from the bladder to the exterior of the body. In the ***male***, urethra provides a dual function: excretion of the urine and ejaculation and conveying of the semen into the female genital organs.

-The **female urethra** is lined with transitional epithelium that

Changes to stratified columnar and ends by non-keratinized stratified squamous epithelium. In some species, the urethral epithelium may show intraepithelial mucus secreting cells.

-The propria-submucosa contains fibroblastic connective tissue with cavernous spaces in some species.

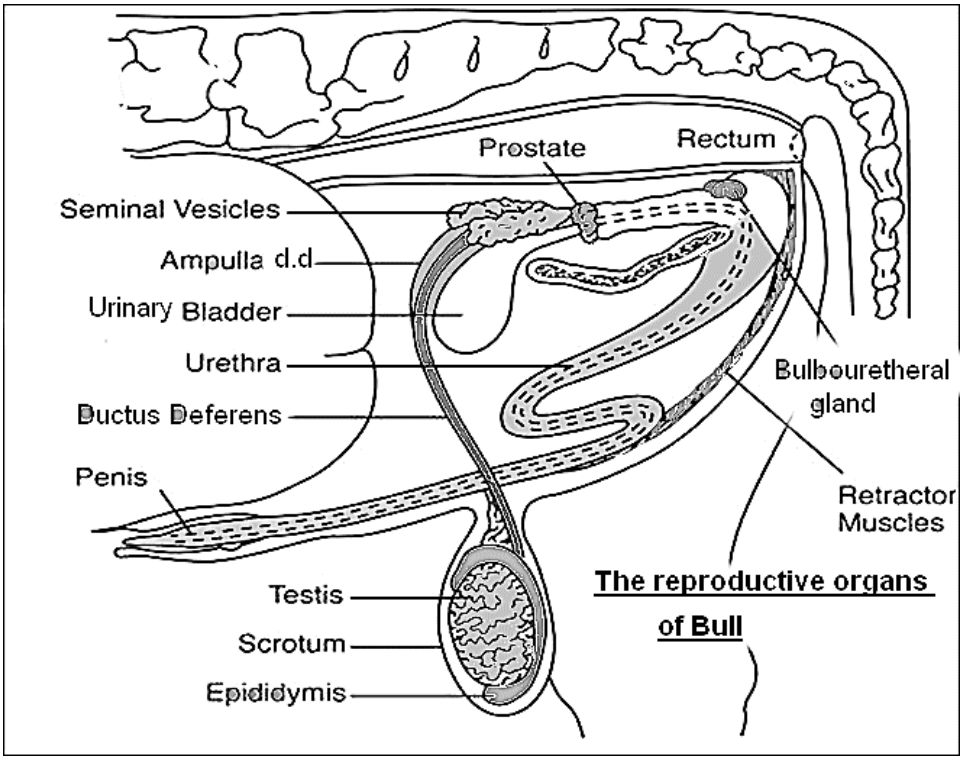
-The tunica muscularis in the proximal part is inner circular and outer longitudinal smooth muscle fibers. Distally smooth muscle fibers are intermixed with striated muscle fibers. -Tunica adventitia, loose fibroblastic connective tissue.

MALE &FEMALE REPRODUCTIVE SYSTEM

Prof. Dr. / Saad Emara

MALE REPRODUCTIVE SYSTEM

The male reproductive system consists of two testes and their duct system (epididymis, ductus deferens, urethra and the penis), together with associated accessory glands (ampullary gland, vesicular gland, prostate, and bulbourethral glands).



TESTIS

The testis is compound tubular gland that has two principal functions exocrine and endocrine at the same time. It forms male germ cells (spermatozoa) and secretes the male sex hormone (testosterone).

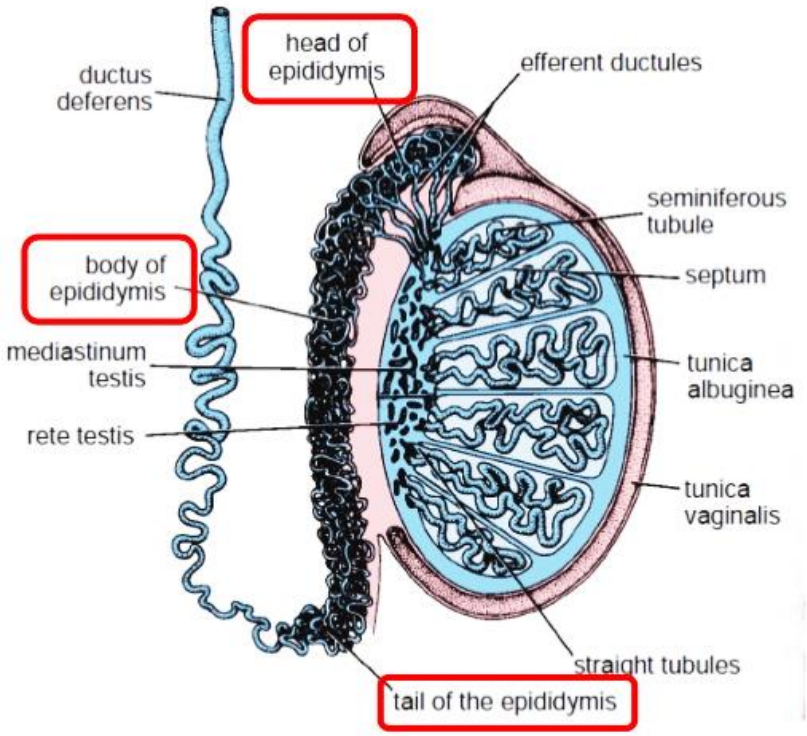
Histological structure of the testis..

The testis is surrounded by an irregular dense fibrous connective tissue capsule, the *tunica albuginea*. It is thin and consists mainly of collagen fibers and a few elastic fibers. In the stallion smooth muscle cells are present. Branches of testicular artery and vein are situated in the *vascular layer*. This layer is located deep to the tunica albuginea in boar and stallion and superficially in the dog and ram. The

visceral layer of the *tunica vaginalis*, the peritoneal covering of the testis (and epididymis), remains attached to the underlying c.t. capsule of the testis.

The ***septula testis***, connective tissue trabeculae are continuous with the tunica albuginea and converge toward the centrally located mediastinum testis. These septula are thick in the dog and the boar, whereas in ruminants and the cat they are thin. They are composed mainly of collagen fibers, contain vessels and nerves, and divide the testis into a varying number of *testicular lobules*. The *intralobular connective tissue* is fine loose connective tissue surrounding the seminiferous tubules contain the interstitial endocrine gland cells. In the prepuberal testis the peritubular cells resemble fibroblasts (*myoid cells*) that acquire the characteristics of smooth muscle cells at puberty. These peritubular cells are responsible for the rhythmic contractions of the seminiferous tubules independent of nerve impulses, gradually moving the spermatozoa toward the *rete testis*.

The ***mediastinum testis*** is loose connective tissue containing the rete testis. In the stallion the mediastinum testis is restricted to the cranial pole of the testis, but it occupies the entire center of the testis in most other domestic animals.



Interstitial cells ..

Interstitial cells (*Leydig cells*) are polygonal cells present in groups which occupy the spaces between the seminiferous tubules. The number of the interstitial cells varies considerably in the different species and is age dependant. They are abundant in the boar and stallion. The interstitial cells are polygonal cells with a spherical lightly basophilic nucleus containing one or two nucleoli. The cytoplasm is acidophilic containing lipid droplets and glycogen granules. The interstitial cells secrete testosterone hormone. Among the function of the testosterone are promotion of the normal sexual behavior (Libido), triggering growth and development of accessory glands and the secondary sexual characters and facilitating action, together with FSH and LH , on spermatogenesis.

Seminiferous Tubules:-

The seminiferous tubules form the parenchyma of the testis. The seminiferous tubules open in the *rete tubules* in the mediastinum testis through the *straight tubules*. The *rete tubules* join variable number of *efferent ductules* (8 – 25) enclosed in the head of the epididymis. The efferent ductules join to form a highly convoluted epididymal duct that courses from the head of the epididymis to its tail where, after a sharp bend, straightens to form the ductus deferens. The seminiferous tubules are long, tortuous tubules. They begin and end by short *tubuli recti* which lead to the rete tubules. They may also branch anastomose or begin blindly. The seminiferous tubules are lined by a stratified epithelium consists of two different basic cell types: - supporting and spermatogenic cells

Supporting cells:-

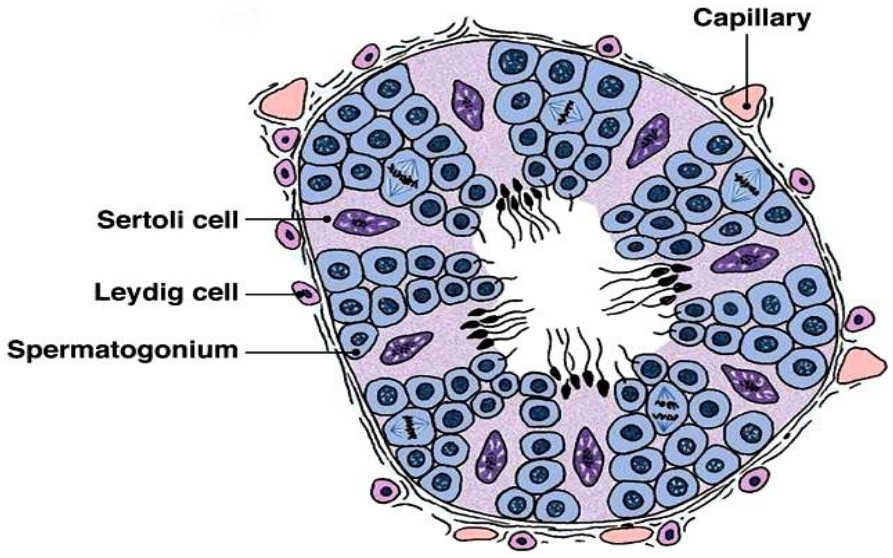
The supporting cells (sustentacular cells, Sertoli cells) are irregular outlined, often elongated pyramidal cells whose broad bases rest on the basement membrane. The apical margin of Sertoli cells present toward the lumen of seminiferous tubule, contains the last spermatid. They are rather evenly spaced, between 25 and 30 supporting cells can be found in a cross section of

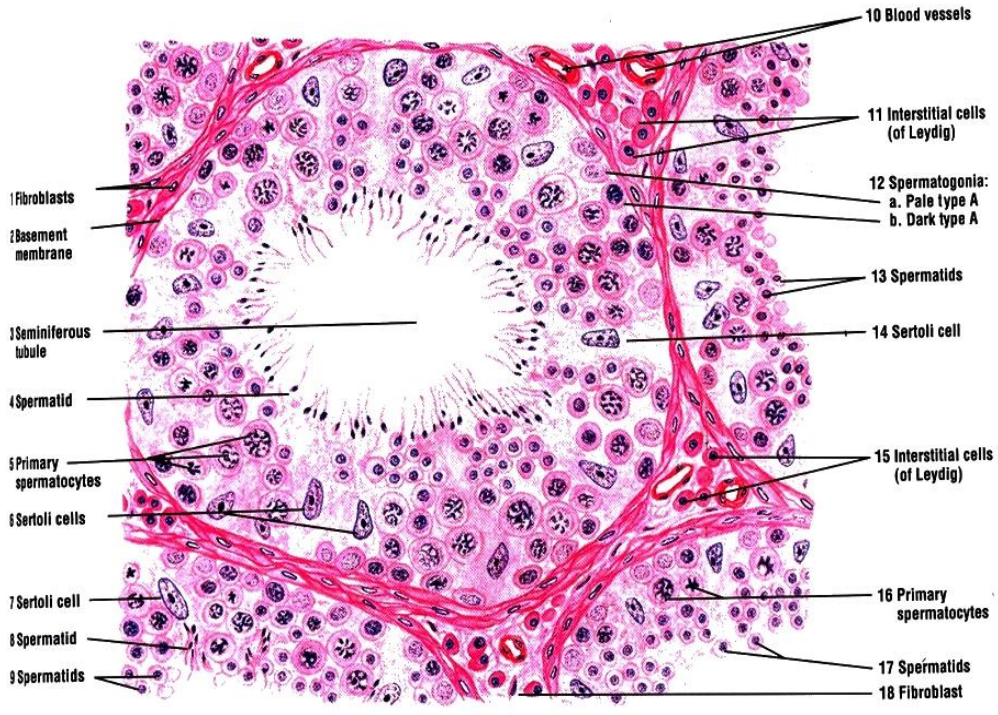
seminiferous tubules in the bull, dog and cat. They wedge the spermatogenic cells in this space. The oval or pear-shaped nuclei are large and lightly stained with clear nuclei, they are generally located in the broad basal portion of the cells. The cytoplasm is clear and poorly defined; it contains varying amounts of lipid inclusion and glycogen. The supportive cells have nutritive, protective, and supportive functions for the spermatogenic cells. They phagocytize the residual bodies of late spermatids and male forming spermatogenic cells. They release the spermatozoa into the lumen of the seminiferous tubules and secrete fluid, the testicular fluid, for sperm transport. They produce small amounts of estrogen, and in prepubertal testis they secrete antiparamesonephric hormone. The supporting cells participate in the formation of *blood – testis barrier*, which protects the developing sperm from autoimmune reaction. Fully differentiated supporting cells are unable to divide.

Spermatogenic cells :

Various spermatogenic cells represent different phases in the development and differentiation of the spermatozoon. They are located between and above the supporting cells. The development of spermatozoa from spermatogonia is referred to as *spermatogenesis*.

The process of spermatogenesis is subdivided into three phases: *spermatocytogenesis, meiosis* and *spermatogenesis*.





Spermatocytogenesis :

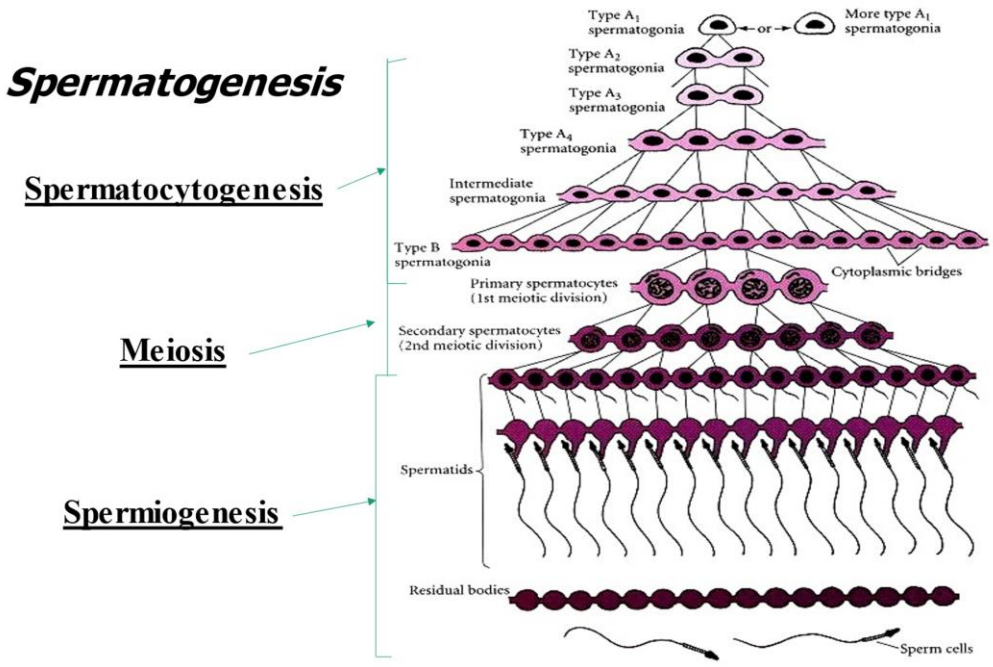
Spermatocytogenesis is the process in which ***spermatogonia*** develops into the *spermatocytes*. Spermatogonia are diploid cells that lie directly on the basement membrane of the seminiferous tubules.

The primary spermatocytes develop into the largest cells of the entire spermatogenic series. The primary spermatocytes are separated from the spermatogonia by cytoplasmic processes of Sertoli cells which run parallel to the basal lamina and are fixed together by tight junctions. These processes divide the lumen of seminiferous tubule into two compartments: *basal compartment* containing spermatogonia and *adluminal compartment* containing the remaining spermatogenic cells. This results in the formation of blood – testis barrier.

Blood–testis barrier is a selective barrier prevent substances circulating in the blood penetrating into the adluminal compartment and prevents protein produced in the testis by speramtogenic cells from reaching the blood stream and cause autoimmune reaction.

Meiosis: -

The primary spermatocytes divide meiotically and give rise to secondary spermatocytes. They are small cells and after short time they enter the second meiotic division to form spermatids. Spermatids are smaller in size and undergo a complex process to form spermatozoa. It is important to know that the germ cells of the same developmental stages, from spermatogonia to spermatids, are frequently, regularly and interconnected by cytoplasmic bridges, this for synchronization of the mutation of the germ cells.

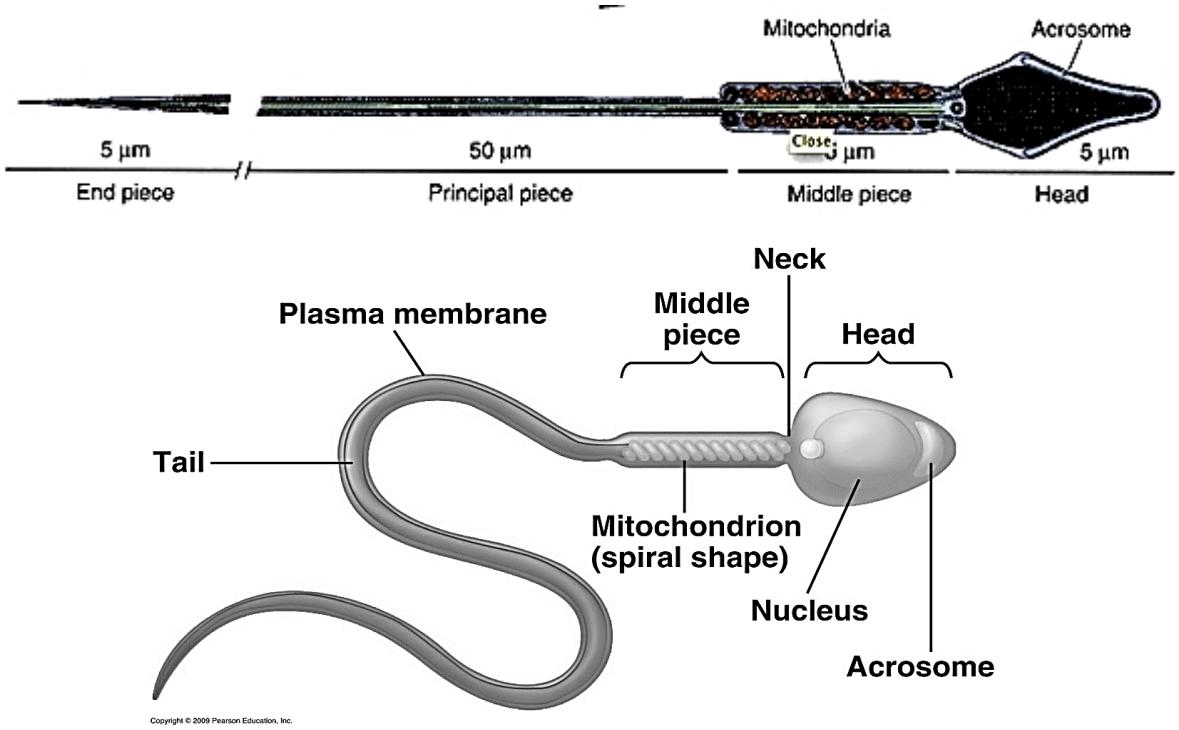


Spermiogenesis:-

The process by which the spermatids differentiate into spermatozoa through a certain number of nuclear and cytoplasmic transformations. Spermatids are small, spherical cells with central spherical nucleus. They are smaller than the secondary spermatocytes. The residual bodies consist of excess cytoplasm containing a few inclusions and organelles.

Spermatozoon:-

With the light microscope, the spermatozoon appears to consist of two portions: the head and the tail. With E.M. the spermatozoon consists of head and tail, but the tail subdivided into : *neck , middle piece , principal piece* and *end piece*.



Straight seminiferous tubules

The Straight seminiferous tubules (tubuli seminiferi recti) connect the convoluted seminiferous tubules to the rete testis. They are long in the *stallion* and *boar* and short in other animals. They are lined with a simple cuboidal or squamous epithelium.

Rete testis

The rete testis is irregular anastomosing canals that are surrounded by the loose connective tissue of the mediastinum testis. The rete tubules are lined by cuboidal or stratified cuboidal epithelium.

EPIDIDUYMIS

The epididymis consists of a long ductus epididymidis and ductuli efferents which connect the rete testis to the ductus epididymidis. Macroscopically, the epididymis is divided into a head, body, and tail. It is surrounded by thick tunica albuginea of dense irregular C.T. covered by the visceral layer of the tunica visceralis.

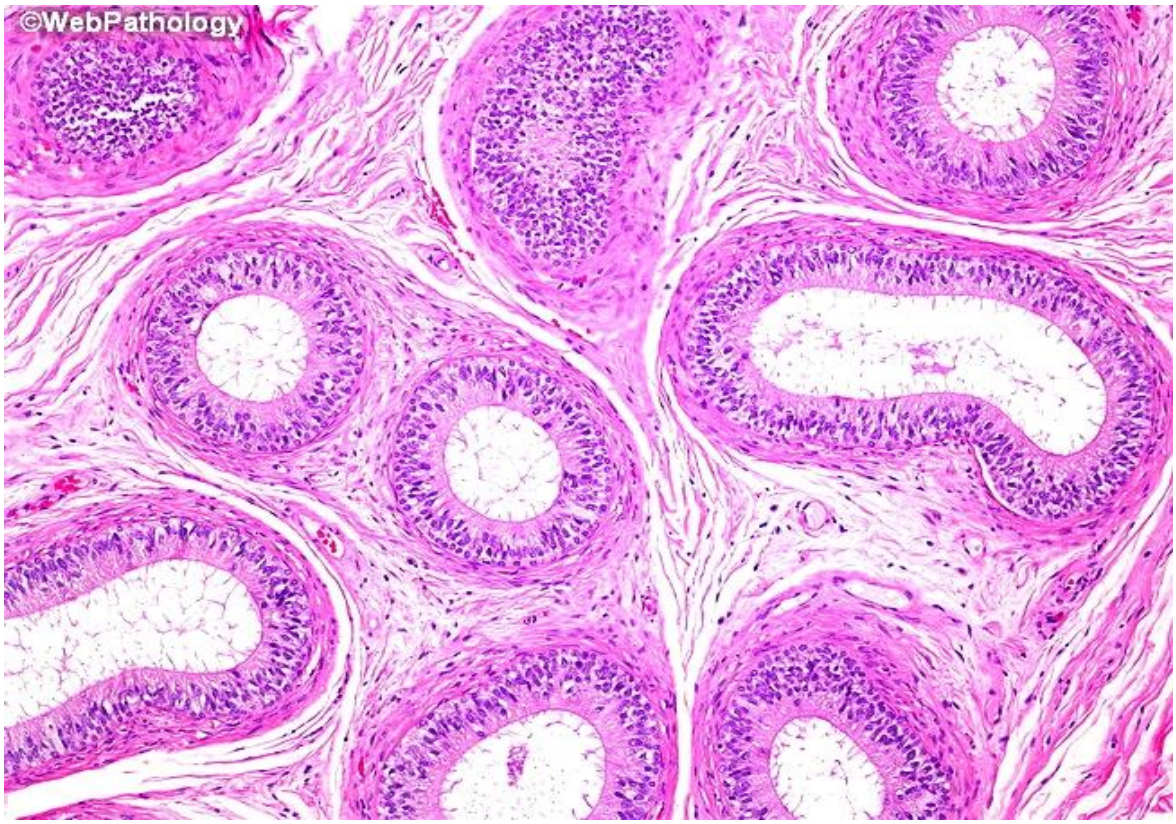
Efferent ducts

The Efferent ducts (ductuli efferents) are between 12 and 25 in number and originate from the rete testis. The lumen is irregular. The efferent duct is lined by intermittent Kino-ciliated high columnar cells and non ciliated columnar cells as well as basal cells. It is surrounded by loose C.T contains smooth muscle fibers (myofibroblasts). The efferent ducts and the initial portion of the ductus epididymidis constitute the head of the epididymis.

Ductus epididymidis:

The ductus epididymidis has an extremely tortuous and coiled course forming the body and the tail of the epididymis. It is lined by pseudostratified columnar epithelium surrounded by loose C.T. and contains smooth muscle fiber. The number of smooth muscle fiber increases gradually toward the tail. The apical surface of the columnar cells has long branching cytoplasmic microvilli (stereocilia).

The epididymis is a place of maturation and storage of spermatozoa as well as correction of testicular fluid.

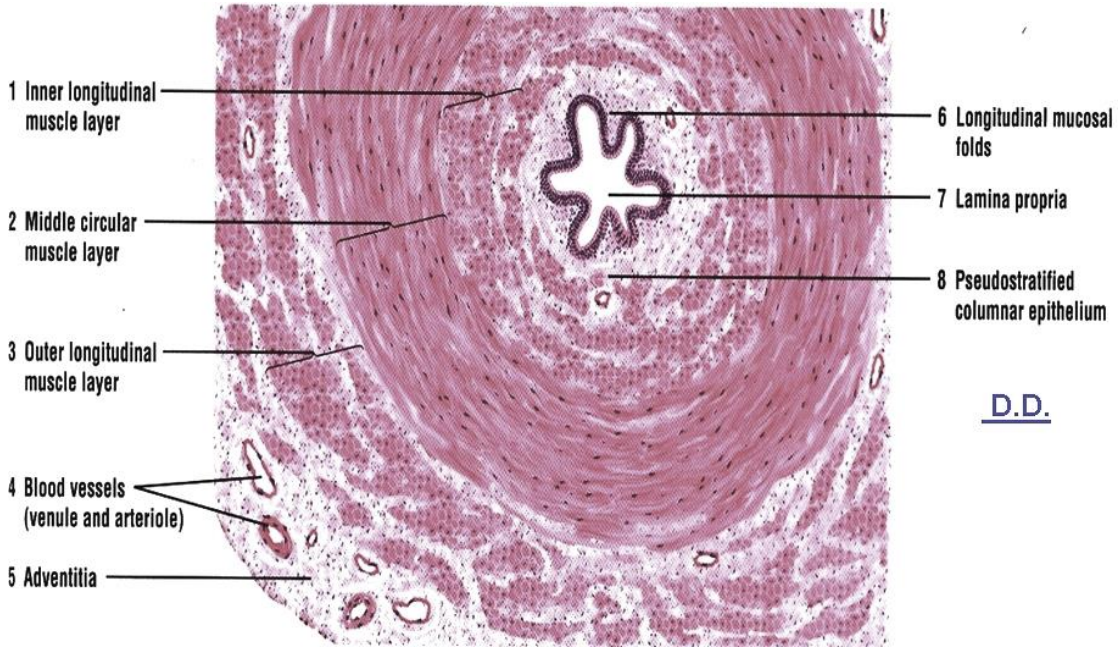


EPIDIDUYMIS

(a) Ductus deferens:-

The Ductus deferens is the continuation of the ductus epididymis after a sharp bend at the end of the tail of the epididymis and ends at the pelvic urethra. The folded mucosa of the ductus deferens is lined along most of its extent by pseudostratified columnar epithelium with microvilli specially at the proximity of the epididymis. Towards its end it may become simple columnar cells.

The propria – submucosa is composed of connective tissue rich in elastic fibers and fibroblasts. The muscular layer is thick, consists of inner circular and outer longitudinal layers of smooth muscle fibers in small ruminants and carnivores, while in other animals the muscle bundles are intermingled. Loose connective tissue tunica serosa or adventitia surrounds the tunica muscularis.



Ductus deferens

THE ACCESSORY GLANDS

The male accessory glands are :

1- the glandular portion of the ductus deferens (ampullary gland).

2- vesicular gland.

3- prostate gland.

4 – bulbourethral gland.

All the glands are present in the stallion and ruminants. The vesicular glands are absent in the carnivores and the bulbourethral glands are absent in dogs. The ampullary gland is absent in cats and boar. These glands secrete serous and mucous secretion that function for nutrition and activation of the spermatozoa, clean the urethra before ejaculation, acts as a vehicle for transportation of the spermatozoa through the female tract and plug the female tract to help ensure fertilization. Generally, all these are lobulated, branched tubular or tubuloalveolar glands. The glandular epithelium is columnar with occasionally small, spherical basal cells. Some of the columnar cells possess a bleb – lick apical projections indicating secretory activity.

1-<u>Ampullary gland</u> :

The terminal portion of the ductus deferens forms an ampulla containing simple branched tubuloalveolar gland in the propria - submucosa. The glands are surrounded by connective tissue containing smooth muscle fibers. The secretory epithelium varies from columnar to cuboidal cells. Often apical bleb – lick protrusions, suggestive of secretory activity are observed. Spherical or polyhedral basal cells are distributed irregularly between the columnar cells. In bull, both basal parts of columnar cells and basal cells contain fat droplets.

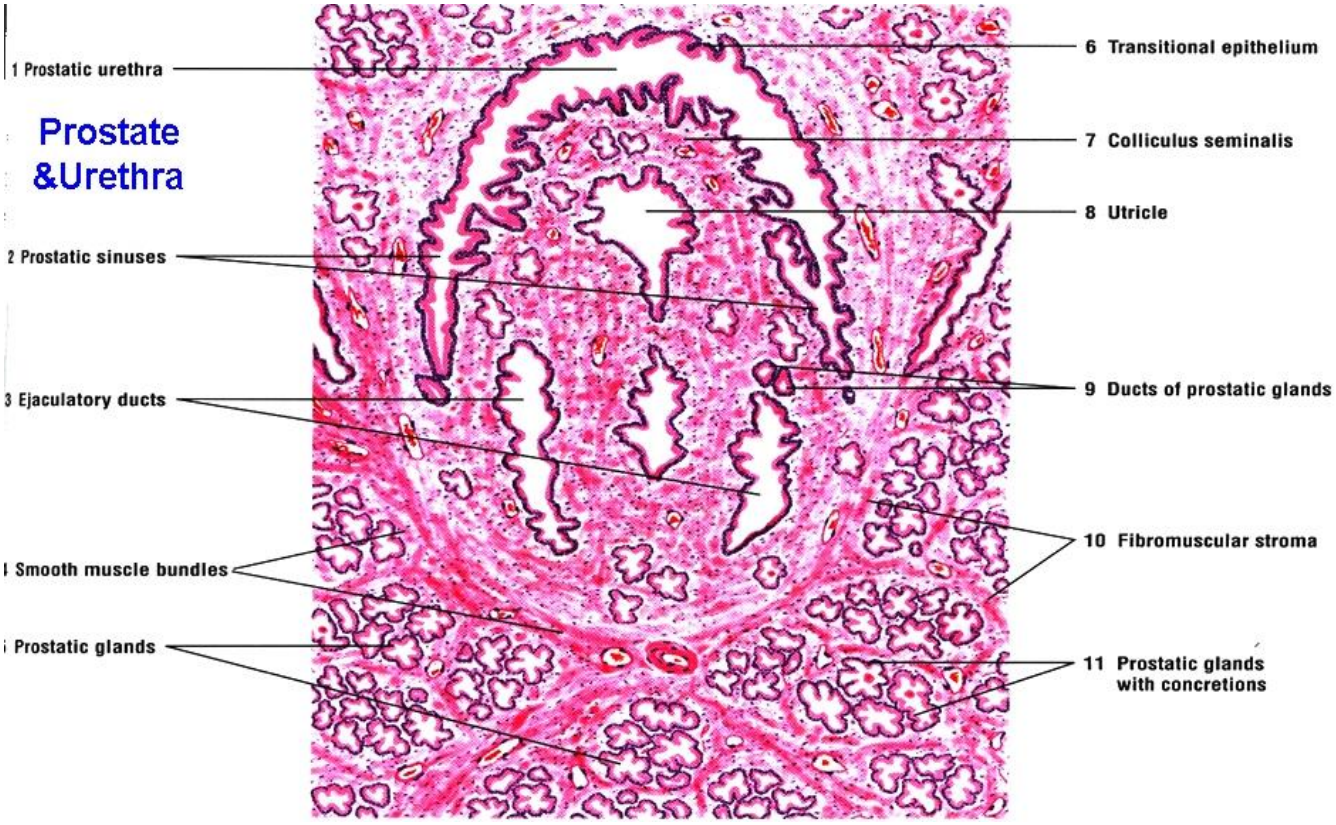
2-<u>Vesicular Gland</u>:

The paired vesicular gland is compound tubular or tubuloalveolar glands

The glandular epithelium is pseudostratified columnar epithelium, showing fat droplets and glycogen in large ruminants. Vesicular glands are true vesicles in stallion. The secretory tubules are surrounded by intralobular connective tissue rich in smooth muscle fibers and highly vascularised propria-submcosa and dense connective tissue trabeculae between the lobes and the lobules. Tunica muscularis varies in width and arrangement and followed by tunica serosa or adventitia. The secretion of gland is gelatinous white or yellowish white product. It is rich in fructose and serve as energy source for spermatozoa.

3-<u>Prostate gland</u> :

The Prostate gland surrounds the pelvic urethra at the level of the colliculus seminalis. It consists of two portions: the compact or external portion (corpus prostate) and the disseminate or initial portion (pars disseminata) The two parts are not developed equally in all species. The corpus prostate is well developed in carnivores and stallions. The disseminate is better developed than the body in the ruminants and boar. The corpus is not distinct in ram. The external portion is located on the dorsal aspect of the pelvic urethra. The disseminated portion is located in the propria – submucosa of the pelvic urethra. The prostate is tubuloalveolar gland with collecting sinuses in the lobules. The secretory cells are cuboidal to columnar with occasional basal cells. The secertory adenomers and ducts are surrounded by loose connective tissue containing smooth muscle cells. The internal portion of the urethra is surrounded by striated urethral muscles.



4-<u>Bulbourethral Gland</u> :

The bulubourethral gland is ensheased by a fiberoblastic connective tissue capsule containing a variable amount of smooth and striated muscle fibers. Trabeculae of the same structure of the capsule extends to divide the gland into lobules. The secretory cells are columnar with occasional basal cells. The secretory adenomeres drain in a centeral collecting duct. The secretory product of the bulbourethral gland serves to nutralize the urethral environment and to lubricate both the urethra and the vagina.

Urethra

The male urethra subdivided into :

1- ***<u>pelvic portion</u>*** from urinary bladder to the level of the bulb of the corpus spongiosum penis. **2**- ***<u>bulbar portion</u>*** and 3- a ***<u>penile portion</u>*** from the end of the bulb to the external urethral opening. The entire urethral mucosa is thrown into longitudinal folds which flatten or disappear during the excretion and micturition. The pelvic urethra is lined by lamina epithelialis of transitional epithelium, that rests on a popria-sbumucosa of fibroblastic connective tissue containing few cavernous spaces. Colliculus seminalis projects at the dorsal aspect. The propria-submucosa contains the disseminated portion of the prostate gland, specially in ruminant and boars. The striated urethral muscle surrounds the urethra, which is surrounded by connective tissue adventitia from outside.

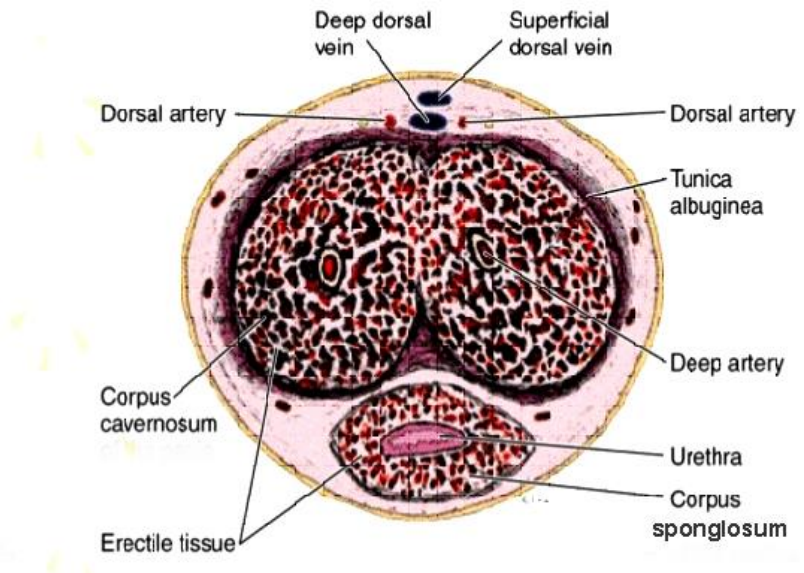
PENIS

The penis is the male organ of copulation. It functions as a common outlet for urine and ejaculates semen. The penis is subdivided into root, body, and glans.

The ***root of penis*** is attached by two crura in the eschial arch of the pelvic bone. The ***body*** or ***corpus penis*** extends from the junction of the crura to the glans penis. The glans penis is the enlarged free end of the penis. It is well developed in stallion and dog. It is covered by a stratified squamous epithelium, devoid of glands and hair. The propria-sub- mucosa has many sensory nerve endings.

Generally, the penis is composed of cavernous blood spaces (erectile tissue) that form two corpora cavernosa penis and one corpus spongiosum and fibrous framework (fibrous tissue) that is arranged into tunica albuginea, septum penis and trabeculae. Morphologically according to the relative proportion of both cavernous tissue and fibrous tissue, there are three types of penises, cavernous penis, fibroelastic penis and intermediate penis. In the vascular or cavernous penis, the cavernous tissue predominates as in stallion. In the fibroelastic penis, the fibroelastic tissue predominates as in ruminants and boars. In the intermediate penis moderate cavernous tissue and fibrous tissue are present as in dog and cat.

Vascular penis



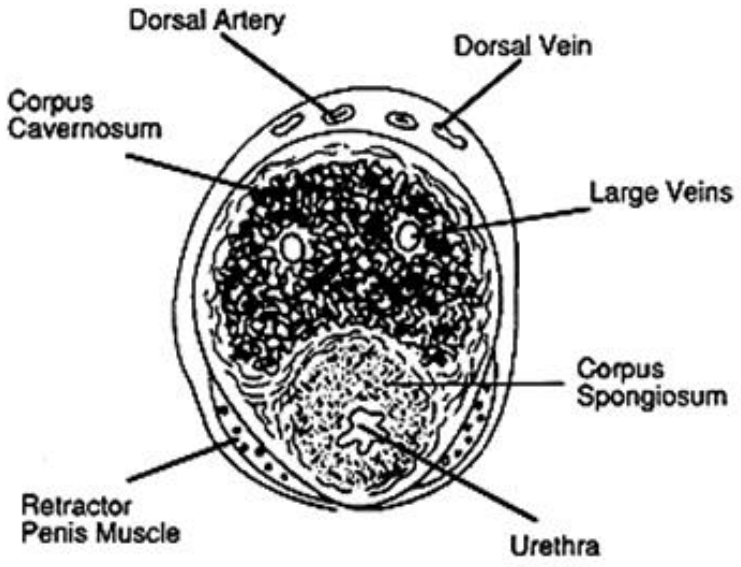
The body of the penis is formed of two dorsal erectile structures: the corpora cavernosa penis that consists of arterial blood spaces lined by endothelium and are separated by connective tissue septum penis (median septum). The corpus spongiosum penis is ventrally located surrounding the penile urethra (spongy urethra) and terminates in the glans penis. It is formed of venous blood spaces. The spongy urethra is lined by stratified columnar or transitional epithelium. The body of the penis is enclosed by the dense fibrous connective tissue tunica albuginea that sends trabeculae to the erectile tissue. Both the trabeculae and the tunica albuginea contain elastic fibers and smooth muscle fibers. The cavernous spaces receive their blood from helicine arteries. The free part of the corpus penis is covered externally by the cutaneous mucous membrane of the visceral prepuce.

Fibroelastic penis

The fibroelastic penis in ruminants characterized by presence of S-shaped sigmoid flexure with dorsal curve cranially and ventral curve caudally. The retractor penis muscle ends just cranial to the ventral curve.

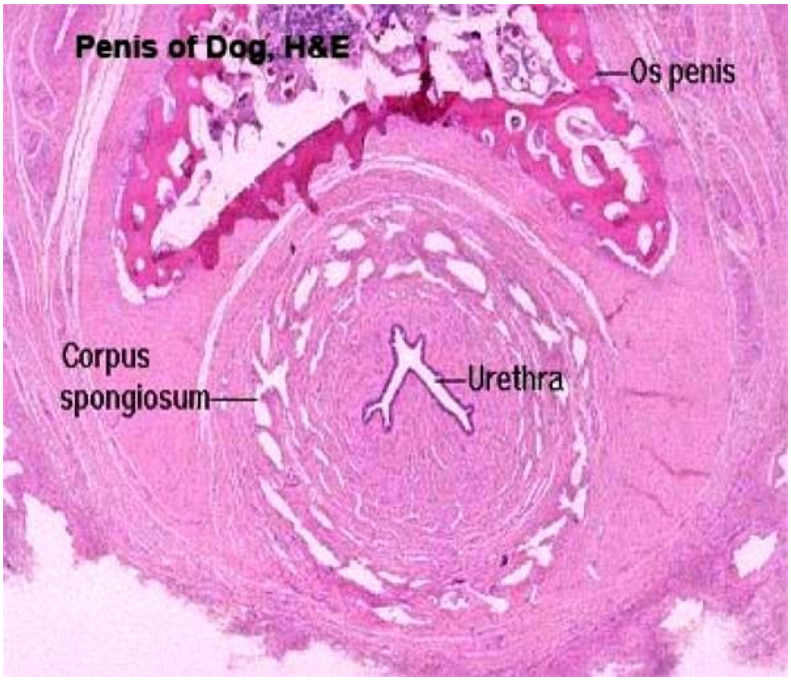
The fibroelastic penis is composed of a thick tunica albuginea. The tunica albuginea forms a closed tube filled with a dense system of trabeculae which traverse in all directions forming a central axial fibrous column from which the trabeculae seem to radiate to the tunica albuginea. The tunica albuginea and trabeculae as well as the central column are composed mainly of fibrous tissue with few elastic fibers.

A small, cavernous blood spaces occurred between the trabeculae represent the corpus cavernosum penis. In the shallow urethral groove, there is the spongy urethra surrounded by the tunica albuginea which encloses the corpus spongiosum.



Intermediate penis

Both the vascular and fibroelastic characteristics are found in the intermediate penis, as in dog and cat. The body of the penis has two corpora cavernosa penis which continue cranially in the glans penis as the os penis. The os penis is an arched long rode of bone that houses spongy urethra with its corpus spongiosum. The corpus spongiosum is formed of venous blood spaces. In the dog, the glans penis consists of a distal long part, the bulbus glandis. The penis is covered externally by visceral prepuce. In cat : the penis of tom cat likes that of the dog. It is an intermediate type. The spongy urethra coarses along the dorsal surface. The glans penis shows the os penis and the visceral prepuce shows cornified papillae directed proximally.



Scrotum..

It is a thin pouch containing testes and epididymis.

Prepuce..

It is a fold as a tube-like reflection of skin covers the glans penis and the cranial portion of the penis.

The semen..

The semen is the normal ejaculate consists of spermatozoa and the seminal plasma a fluid that provides the nutrients for the metabolism and motility of the spermatozoa.

FEMALE REPRODUCTIVE SYSTEM

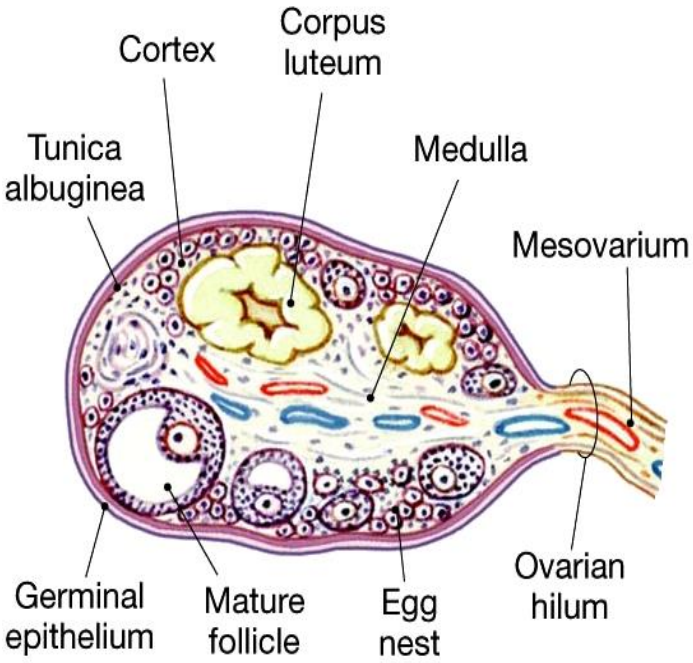
The female reproductive system in domestic animals consists of bilateral ovaries and uterine tubes (oviducts) a bicornuate uterus, cervix, vagina, vestibule, vulva, and associated glands. The female reproductive system is concerned with the production and transport of ova, transport of spermatozoa for

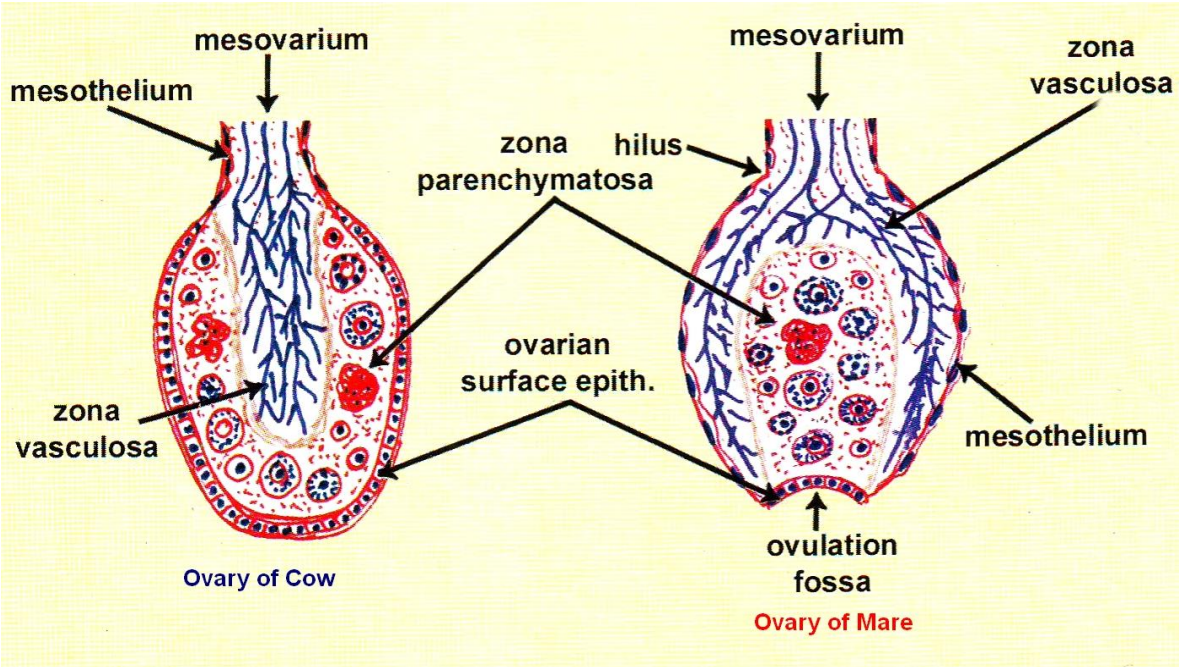
fertilization and the accommodation of the conceptus until birth. This in addition to production of the female sex hormones as well as milk.

1- OVARY

The ovary is a combined exocrine and endocrine gland. It produces both ova (exocrine secretion) and estrogen and progesterone (endocrine secretion). The shape of the ovary is oval or ovoid tuberculated in most domestic animals and is discoid highly tuberculated in she-camel. The ovary of mare is bean-shaped with a depression at one side called the ovulation fossa. The structure of the ovary varies greatly with the species, age, and phase of the sexual cycle. In all animals except mare, the whole surface of the ovary is covered by simple cuboidal epithelium called the ovarian surface epithelium that is continued with the mesothelium of the mesovarium at the hilus. In mare, the ovarian epithelium covers only the ovulation fossa, while the rest of the ovary is covered by mesothelium. Tunica albuginea, a dense fibrous connective tissue layer (capsule) presents beneath and parallel to the surface epithelium. The ovary in all animals except mare, is divided into an outer ***cortex*** (**zona parenchymatosa**) peripherally and an inner ***medulla*** (**zona vasculosa**) internally. In the mare these areas are reversed, and the cortex is limited to the ovulation fossa and the medulla is peripherally except at the ovulation fossa. **Zona parenchymatous** (***cortex***) consists of ovarian follicles, and corpora lutea at various stages of development and regression, embedded in the stroma. The stroma of zona parenchymatosa contains fine collagenous and reticular fibers and a high number of stroma cells. The stroma cells have spindle nuclei and run in various directions, are parallel to the tunica albuginea and surrounding the follicles and blood vessels. In the rodents, dogs, and cats the stroma contains interstitial gland cells. **Zona vasculosa** (***medulla***) consists of loose connective tissue containing nerves, many large and coiled blood vessels, and lymphatics as well as smooth muscle fibers that are continuous with those in the mesovarium. Vestigial rete

ovarii are located in zona vasculosa. In mare, zona vasculosa is formed of highly vascular connective tissue.

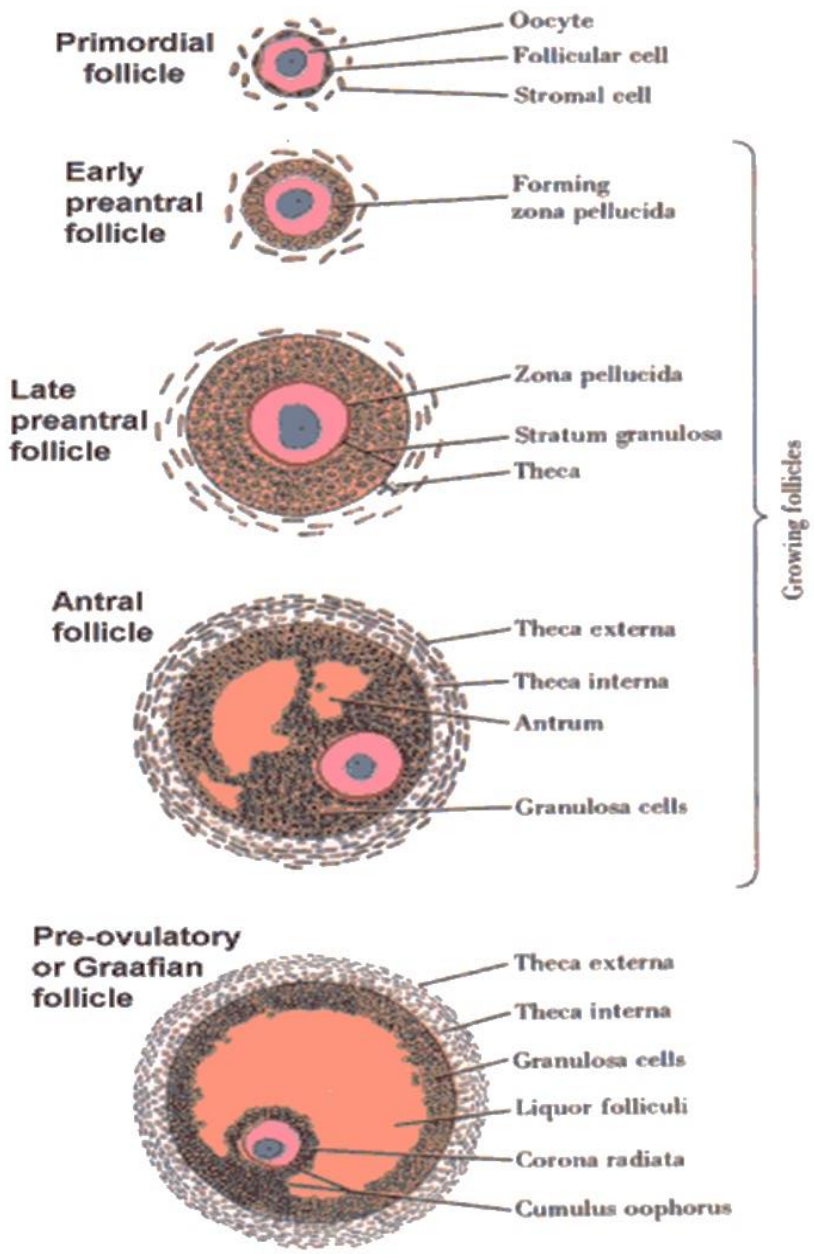




OVARIAN FOLLICLES:-

They are aggregation of cells contain the female gametes in different stages of development. The *primordial follicle* consists of primary oocyte surrounded by a single layer of flattened follicular cells resting on a basal lamina. The primary oocyte has an eccentric large lightly stained nucleus with prominent nucleolus. The primordial follicles are distributed in the outer zone of the cortex evenly in ruminants and sow and in clusters in carnivores. At puberty and under the effect of FSH of pituitary gland, the primordial follicle enlarges to form growing follicle till mature (Graafian) follicle. The *primary follicle* consists of primary oocyte surrounded by cuboidal follicular cells. The *secondary follicle* consists of primary oocyte surrounded by stratified follicular cells. Zona pellucida surrounds the oocyte beneath the follicular cells that are surrounded peripherally by basal lamina. The surrounding cortical stroma cells begin to differentiate and surround the follicle forming *theca folliculin*. As the development proceeds, the follicular cells increase in the size and number and formation of fluid-filled cavities between them. The theca folliculi differentiates into *theca interna* and *theca externa*. The different fluid-filled cavities fuse into a single large cavity called *antrum folliculi* filled with *liquor folliculi* (follicular fluid). This results in the follicular cells is separated into cells attached with the primary oocyte called *comulus oophorus* and a peripheral layer rest on a basal lamina called *membrana granulose*. The cells that surround the oocyte change into columnar cells and are called *corona radiata*. Zona pellucida increases in thickness. This follicle now is called *mature follicle*. The cells of corona radiata have basal cytoplasmic processes and the oocyte membrane carries microvilli. Both cytoplasmic processes and microvilli pass through the pores of zona pellucida giving their striated appearance. The primary oocyte in most species *except mare* and bitch completes the first meiotic division to become secondary oocyte just before

ovulation. In mare and bitch both meiotic divisions are completed after ovulation.



Ovulation..

The ovulation process is the rupture of mature follicle and release of the oocyte with some follicular fluid through *stigma*. Some preovulatory changes take place causing the mature follicle to protrude from the surface of the ovary. Under the effect of LH and FSH the antral fluid accumulation increases, and the most protruded part of the follicular wall becomes very thin and weak form ovulation

site called *stigma*. The theca interna shrinks and the comulus oophorus disintegrate. Finally, the follicle ruptures and the oocyte escapes into the peritoneal cavity toward the infundibulum of the uterine tube.

Atresia..

Several hundred thousand to a million potential oocytes may be present in a single ovary at birth in various species. Only several hundred of those ovulate during a lifetime. Most of them degenerate or become atretic either as primordial follicles or after some degree of development. In some atretic follicles theca interna and granulosa cells may increase in size and store lipid droplets forming an *interstitial gland cell*, especially in bitch and queen. They are polyhedral, steroid (androgen) secreting cells.

Corpus luteum..

After ovulation, the follicular wall of the ruptured follicle collapses and the follicular cells are thrown into folds around a residual lumen that contains few bloods clot and follicular fluid, so called *corpus haemoragicum*. The follicular cells (membrana granulosa) form the large lutein cells. They are large polyhedral cells with large spherical nuclei and the cytoplasm contains lipid droplets. The theca interna cells form small lutein cells. In cows, mares and carnivores, a yellow pigment, lutein appears in the lutein cells. The *corpus luteum* is composed of cords and clumps of lutein cells supported by reticular fibers in the form of lobules separated by connective tissue septa. The corpus luteum is surrounded by connective tissue capsule. Corpus luteum is supplied by blood capillary net and becomes a typical endocrine gland. If fertilization takes place, the corpus luteum persists during pregnancy as *corpus gravidatis*. Then it begins to degenerate shortly before birth. It changes to *corpus alpicans*, a fibrous scar tissue.

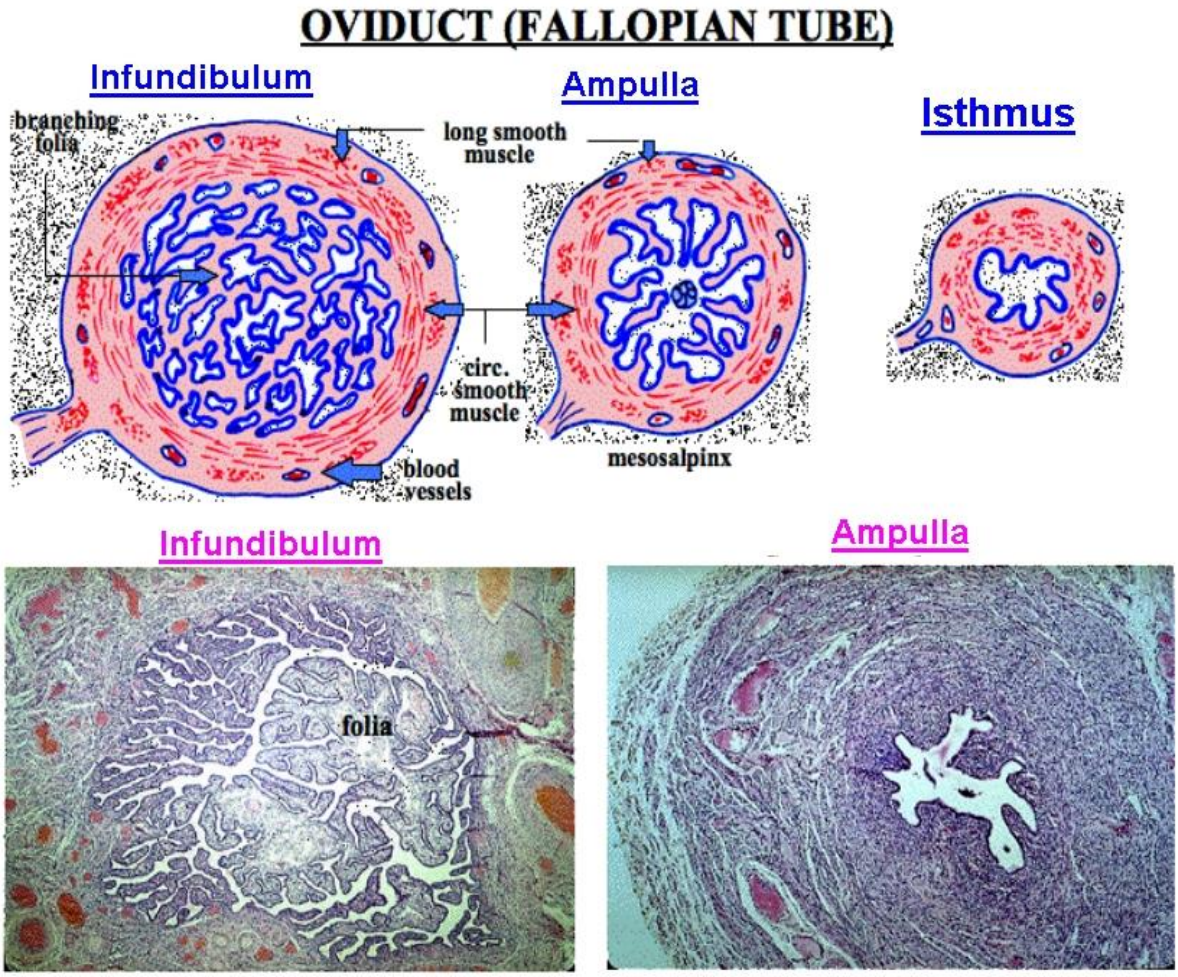
If fertilization does not take place, the corpus luteum begins to degenerate.

2- Uterine tube..

The uterine tubes are bilateral Musculo membranous tubes extending from the ovary to the uterine horns. They transport the ova and spermatozoa. Based on morphological differences, the uterine tube is divided into three segments: the infundibulum, ampulla, and isthmus. In some species there is a fourth segment called intramural part. The infundibulum is the funnel shaped cranial part of the uterine tube. Its free end has fimbriae. The ampulla is the longest segment and has a wide lumen and thin wall. The isthmus is a short part connected to the uterus.

Histological structure of uterine tube:

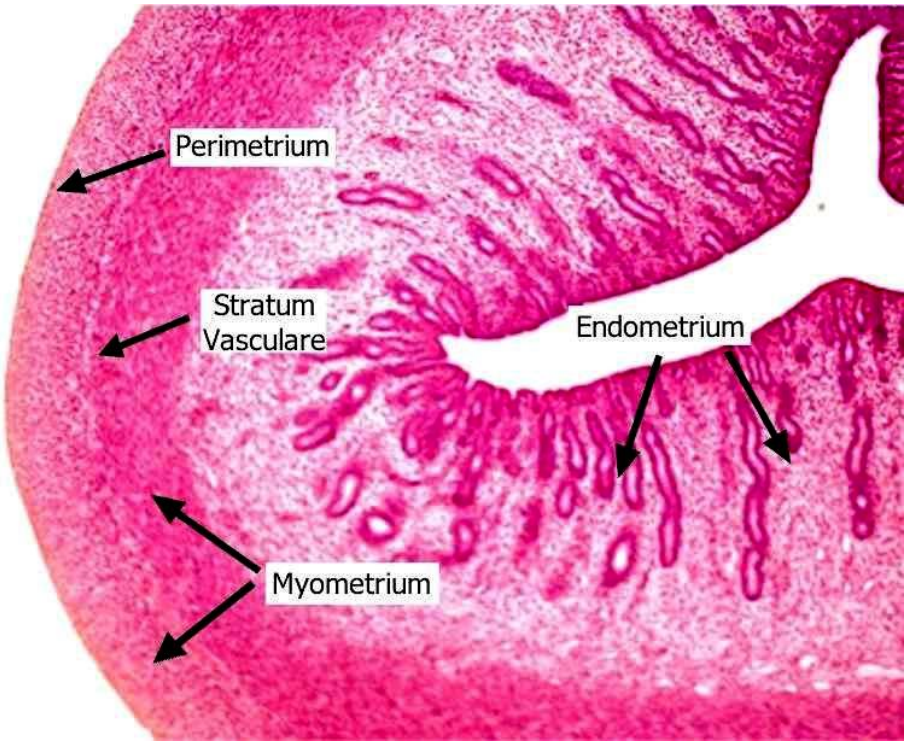
The tunica mucosa-submucosa forms folds as longitudinal folds. These folds are few in the isthmus and are increased greatly in the ampulla, as primary, secondary, and tertiary folds. The lining epithelium of the uterine tube is simple columnar or pseudostratified columnar cells of two types: - ciliated with motile cilia and non-ciliated cells are secretory. The lamina propria and submucosa are formed from loose connective tissue with numerous mast cells, plasma cells, and eosinophils. There is no muscularis mucosa. The tunica muscularis is formed from two layers of smooth muscle bundles, an inner circular, and an outer longitudinal layer. The tunica serosa contains many blood vessels, nerves in loose connective tissue and covered by peritoneal mesothelium. The subserosal layer is rich in fat cells specially in bitch.

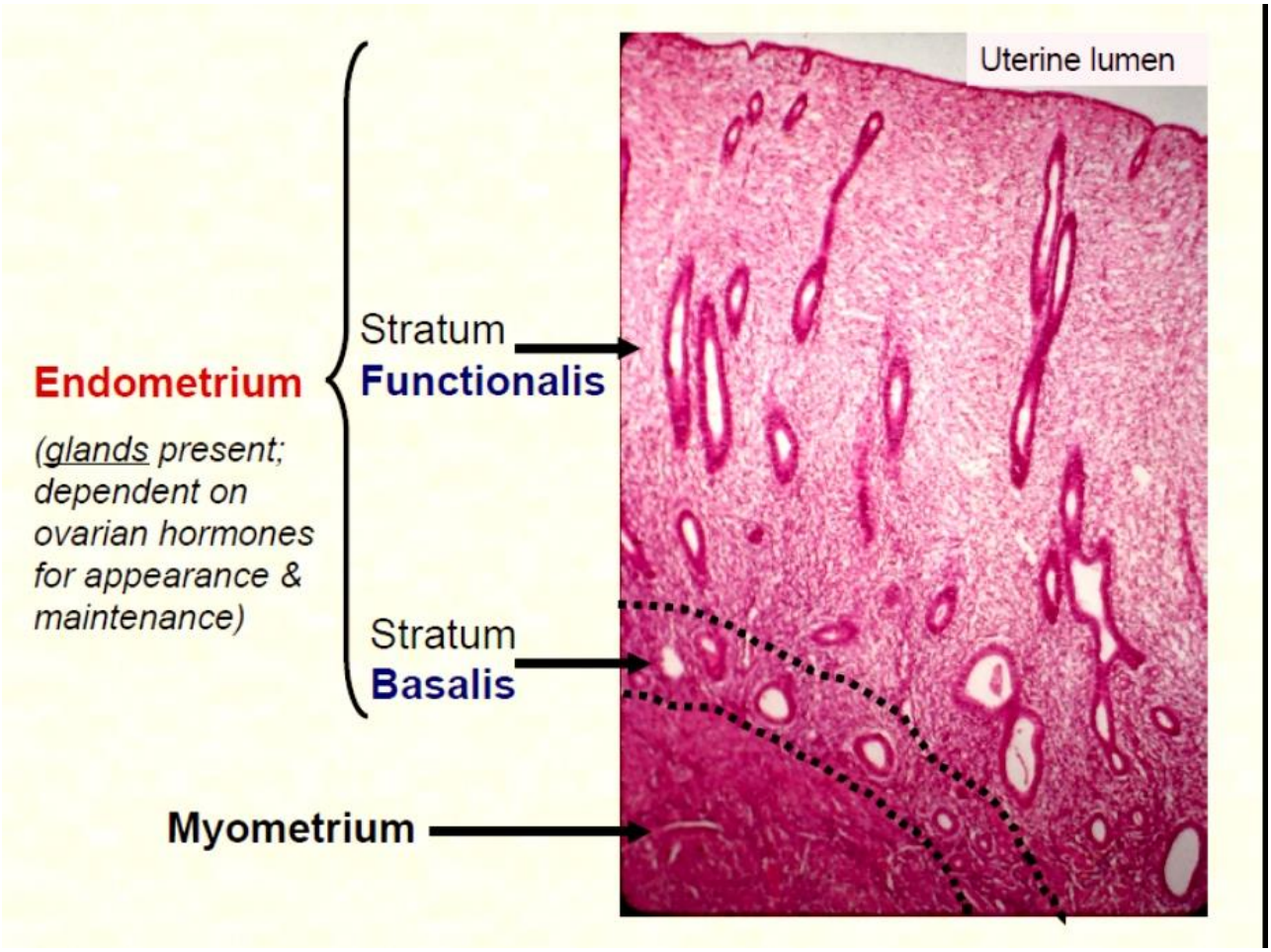


3- UTERUS

The uterus of domestic animals is *bicornuate* type. It is composed of the uterine horns, body, and cervix. The horn or cornea is connected to uterine tube, and the cervix joins to vagina. The *histological structure of the uterine horns and the body*:- Three layers are present in the wall of horns and the body: The endometrium (tunica mucosa-submucosa), the myometrium (tunica muscularis) and the perimetrium (tunica serosa). The uterine epithelium is simple columnar in mares and carnivores and ranges from simple cuboidal to pseudostratified columnar in ruminants and sows. The propria-submucosa is highly vascularized, loose connective tissue with many cells. It contains simple branched coiled tubular uterine glands, that secrete uterine milk (cytotroph). The propria-submucosa is subdivided into two zones, a superficial functional compact zone

(stratum compactum) and a thin deep basal zone (stratum basale). The superficial functional zone contains many fibrocytes, macrophages, mast cells, eosinophils, lymphocytes, and plasma cells. Many melanophores are present in ewe. The upper portion of the uterine glands are present in the functional zone. The basal zone is a thin layer of loose connective tissue surrounding the blind ends of the uterine glands adjacent to the myometrium.



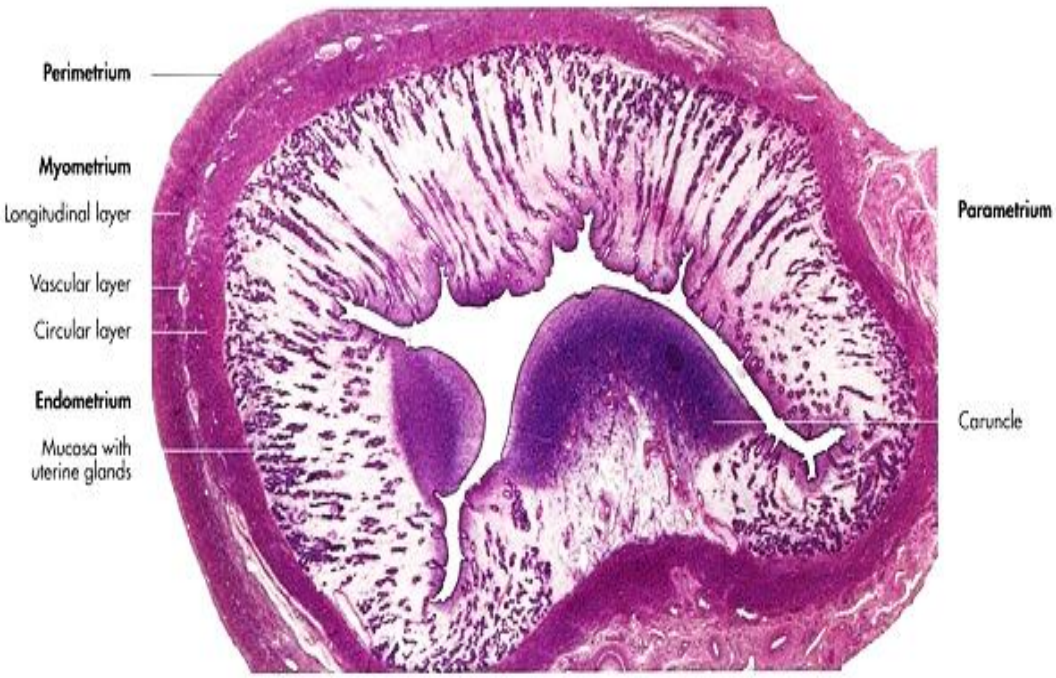


In ruminants, glandless and highly vascularized local thickenings of the propria-submucosa containing numerous fibrocytes are called ***caruncles***. They are dome-shaped in the cows and cup-shaped (has a central depression) in the ewes. The caruncle forms the maternal part of the placentome. The uterine glands present deeper to the caruncle and open in the intercaruncular area.

Placentomes are the sites of attachment between maternal and fetal placental tissues where metabolic interchange occurs.

Myometrium.. It consists of a thick inner circular and an outer longitudinal layer of smooth muscle fibers which increase in number and size during pregnancy. Between the two layers is a vascular layer (stratum vascular) consisting of large arteries, veins, and lymph vessels. The **perimetrium**, the longitudinal muscle layer and the vascular layer of the myometrium, are all

continuous with corresponding structures of the broad ligament of the uterus at the parametrium.



The histological structure of the cervix uteri :-

The cervix is the most caudal portion of the uterus. Its structure reflects its function as a barrier between the vagina and the body of the uterus. The mucosa is highly folded. The lining epithelium in most animals is high columnar mucous secreting cells (mucigenous cells) with goblet cells and a few ciliated cells. The mucous secretion is thin and increased during estrus and is thick forming the *cervical plug* or *seal*.

VAGINA

The vaginal mucosa forms low longitudinal folds and a few circular folds. The epithelium is stratified squamous non-keratinized, but patches of simple columnar epithelium with mucigenous cells and goblet cells occur, specially between the folds.

VESTIBULE

The vestibule is demarcated from vagina by a rudimentary fold, the *hymen.* In most domestic animals, hymen is absent or is represented by a ridge of mucosa.

EXTERNAL GENITALIA

Vulva..

The vulva is formed by the external labia vulvae. In most domestic animals, only one pair of labia is developed corresponding to labia minora in humans. The labia are covered by skin rich in apocrine and sebaceous glands as well as fine hairs. Striated muscle fibers of the constrictor vulvae muscle are found under the dermis.

Clitoris..

The clitoris is homologous to the penis of male. It consists of corpus cavernosum clitoridis, glans and prepuce.

MAMMARY GLANDS

The mammary glands are specialized skin glands, developed from ectoderm. Their growth rate is very slow during prepuberal period and in *female* the rate is increased following puberty due to cyclic hormones. The mammary glands reach their greatest development at the end of pregnancy during the lactation period shortly after parturition.

In *male*, rudimentary mammary glands are present as few ducts embedded in fat.

The mammary glands are compound tubuloalveolar glands. The secretory unit (parenchyma) consists of alveoli and ducts, both with a similar structure. Groups of secretory units form lobules separated by connective tissue septa. An *intralobular duct* opens into an *interlobular duct* in the connective tissue septa,

where several of them form the *lactiferous duct* which drains a lobe of the gland. In *ruminants*, several lactiferous ducts empty into lactiferous sinus at the base of the teat. This sinus is continuous with a teat sinus that opens to the outside by way of simple teat canal. The lactiferous ducts of the other species open separately. The *alveolus* is lined by a layer of simple cuboidal that varies in height during various stages of secretory activity. Myoepithelial cells are found between the lining epithelium and the basement membrane.

The *active lactating mammary glands* have little connective tissue stroma and much parenchyma. The lobules are packed with secretory alveoli separated by thin connective tissue septa and supported by reduced intralobular connective tissue. The *connective tissue stroma* is fibroelastic connective tissue that contains blood and lymph vessels and nerves. Plasma cells and lymphocytes are common

constituents particularly at parturition. In the *synthesis stage*, the alveoli are lined with high columnar cells with bleb-like projections on the luminal border of the cells. In the *exhausted stage* (after milking), the alveoli are lined with cuboidal epithelium.

The <u>non-lactating mammary gland</u>..

has more interstitial tissue than glandular elements. Fat cells may occur singly or in clusters. The parenchyma consists of isolated ducts and non-functional small alveoli lined with a low cuboidal epithelium with myoepithelial cells.

The **duct system** begins with intralobular ducts, in-between the alveoli and are lined by simple cuboidal epithelium. The intralobular ducts drain into interlobular ducts which are lined by bistratified cuboidal epithelium. The interlobular ducts continue into lactiferous ducts, which open into the lactiferous sinus. Both lactiferous ducts and sinuses are lined with bistratified cuboidal to columnar epithelium.

The teat..

The teat or nipple contains the terminal part of the duct system. The teat of ruminants has a large lumen, the teat sinus, which is lined by a two-layered cuboidal epithelium. The teat sinus is continuous with the outside via the teat canal. The teat canal is lined by stratified squamous epithelium that rests on fibroelastic connective tissue lamina propria.

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